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The evolution of South African wastewater effluent parameters and their regulation: A brief history of the drivers, institutions, needs and challenges

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Understanding the historical context of sanitation provision and wastewater disposal is essential to understanding its regulation. The aim of this article was to provide that context for South Africa, interweaving the story with social, institutional, policy and technological developments over more than two centuries. Given that so much was initially developed in Europe or encountered in Europe, it was subsequently adapted for use in South Africa. The article begins in earnest with the population disruptions which accompanied the Industrial Revolution, drawing parallels between the scale of these disruptions and the 20th- and 21st-century mass urbanisation in the developing world. Thereafter the article dealt exclusively with South Africa, highlighting the major reversal of policy in the mid-20th century, prior to which time wastewater could not be discharged to watercourses, whereafter treated wastewater could only be discharged to watercourses. The article then spelt out some key current regulations, especially with respect to the skills required, and some difficulties in applying the regulations.

Introduction

Understanding the historical context of sanitation provision and wastewater disposal is essential to understanding its regulation.

The article begins by describing the great social disruptions – also the institutional and technological advances – which accompanied the late 18th-century through 19th-century enclosures of the commonage, growth of the Industrial Revolution and the phenomenal urban development in pace-setting Europe.

Although in all of the above, frequent reference is made to developments in South Africa, the second half of the article deals exclusively with South Africa, commencing with a broadly chronological description of urban development and the growing need for wastewater disposal and treatment. Attention is drawn to the major shift of policy in 1956 – prior to that wastewater (not even treated wastewater) could *not* be discharged to watercourses (certain exceptions permitting), but after that treated wastewater could *only* be discharged to watercourses. The article then spells out some key current regulations, especially with respect to the skills required, and some difficulties in applying the regulations.

Prior to the industrial age

Up to less than 200 years ago, even in Western Europe, sanitation practices and wastewater collection and treatment had not advanced much for many centuries. Isolated inventions, such as the water closet in Elizabethan times, were adopted by only a very few households. Human and animal waste was, for the most part, simply dumped in the street. Collection was intermittent and usually organised by the local parish council in the absence of more formal municipal government other than (sometimes) in the larger urban settlements. Cesspits were common in these larger cities, at least in Europe – emptying of these was intermittent, and during the intervals the liquid part of the cesspit waste would drain into the groundwater.

Water conservation was largely a non-issue in countries with adequate rainfall. Major (for the times) engineering works, such as aqueducts, brought water to cities,[1] but in other settlements, rivers or streams were seldom far away – populations were low compared to today, and settlements were small and very compact. In European formal settlements, the parish or some other authority would organise a water supply to a fountain in the town square (if a larger settlement, there

1.Notably those constructed by the Roman and Ottoman empires.

Source: Photo taken by Kevin Wall

FIGURE 1: Remains of the wash troughs next to the Platteklip Stream.

would be several of these fountains), and the townspeople would fetch their water supply from these fountains. Other supply would be obtained from wells or furrows.[2] In dry countries, water was collected and stored with great care, but again, the technologies hardly changed, if at all, in centuries.

None of which is to say that many of the practices were not flawed. A particular issue, for people dependent for their water supply upon fountains, wells, springs, streams or canals, was pollution by other users. For example, within a year of his 1652 arrival at the Cape, Commander van Riebeeck felt compelled to issue a 'placaat', or proclamation, surely the very first environmental regulatory measure enacted in colonial South Africa. Although the settlement had been established primarily as a refreshment station between Holland and the East Indies, and the site had been carefully chosen to secure supplies of clean water from the 'Fresh River' flowing from the slopes of Table Mountain, some ships reported sicknesses which they ascribed to the supposedly clean water, not in fact, being clean. It was readily discovered that people in the settlement upstream of the shoreline were washing in the stream or dumping their refuse into it. Hence the proclamation to the effect that any such practice was forbidden on pain of a fine being levied (Figure 1).

During the latter part of the 19th century, the municipality provided off-stream wash troughs as an incentive to washerfolk not to wash clothes in the stream.

The 19th century

From the late 18th century, the pace of change increased rapidly in response to far-reaching social and institutional change, together with medical, scientific and technological advances. The first country to experience radical change was Britain. With the Industrial Revolution there appeared both a compelling cause and an enabling force of these other advances.

'Largely' a British story, yes, but by no means 'only' a British story. Several other countries in Europe and North America generally started later, but then followed close behind – or made their own contributions before the British did.

2. If the founding fathers of the settlement perceived the need, and if the topography suited, furrows would be laid alongside the main streets – this was also recognition of the demand for plots, even within the settlement, to be irrigable. Quite a few South African settlements were laid out on this basis. Furrows still run in Stellenbosch and Stanford, for example.

The more urbanised parts of British colonies, such as the south-western Cape Colony, were often not far behind in terms of adoption of any innovations.

As briefly as possible:

- In Britain, scientific, industrial and other advances picked up momentum in the late 18th century and quickened as the 19th century progressed. The story is well known – to name a few advances: early steam engines, the building of canals, early experiments with electricity and chemistry and so on – and there is no need to list them here.
- Intensified enclosure of the commonage from the late 19th century deprived many countryfolk of their livelihood, pushing them from the land.
- The growing demand for industrial workers drew many countryfolk to towns.
- Thus towns grew. Spectacularly so, in some cases, if the town became an industrial hub.
- The flood of people into the industrial towns overwhelmed the existing infrastructure and technologies for sanitation, water supply and clearing of refuse.
- Existing governance institutions – for example, the parish councils – were also overwhelmed.
- The average living conditions in these towns deteriorated rapidly.

Reform was clearly needed, but it had to surmount four major obstacles, namely:

- absence of the *political will to act*
- lack of effective and properly resourced *institutional and administrative machinery* – to govern, to plan, to implement and to regulate
- *knowledge of how to act*, including the necessary engineering and medical technology
- need for a vast improvement to the *basic education* system.

The parallelism between 19th-century Britain and that of the 20th and 21st centuries:

> … the cities of the developing world is, in several ways, exact. The people who flooded into the burgeoning 19th century industrial and port cities of Britain … tended to be drawn from the poorer section of the rural population …. They had little or no knowledge of the technical skills needed by the new industry, or of the social and technical necessities of urban life. (Hall 1974:23)

Nearly two decades ago, the then Director General of Water Affairs (DWAF), commenting on the perceived slow pace of water and sanitation improvement in post-1994 South Africa, stated that:

> We really do need a sense of history. Local government was born of the pollution, poverty and pestilence of 19th century imperial Britain. In 1850, the British solution to cholera was to build local government and have local government build sanitation and water infrastructure. *It took time*. Fifty years later, the army generals complained that poverty and disease had produced a population so stunted that it was difficult to muster a credible army to fight in South Africa. (Muller 2001 – emphasis added by current author)

Source: Punch 1855, reproduced in Halliday, S., 1999, *The great stink of London: Sir Joseph Bazalgette and the cleansing of the Victorian metropolis*, p. x, Sutton Publishing, Stroud, Gloucestershire

FIGURE 2: The scientist Michael Faraday presenting his business card to a stinking dirty Father Thames.

It was only part of the problem that these migrants to the settlements were poor and lacked skills suitable for any employment other than that requiring the lowest levels. A bigger part was that their numbers overwhelmed the towns to which they emigrated – which in any case prior to their arrival had only the most rudimentary arrangements for providing water, or clearing refuse or sewage, or for treating mass epidemics. There was no way the towns could cope with the huge influx. London's population doubled from 1 million in 1801 to 2 million in 1851; doubled again to 4 million in 1881 and reached 6 million in 1905.

The results were predictable. Limited water supplies became even more overstretched and also increasingly contaminated; arrangements for disposal of wastes of all kinds were unable to cope; personal hygiene was very poor; and public health controls were almost completely lacking. Take London: nearly all of its wastes eventually found their way into the Thames. At the height of summer in 1856, Parliament was unable to sit because the stink from the adjacent river was unbearable (Figure 2).

Reform was clearly needed, but it had to surmount the 'major obstacles' listed above.[3]

The political *will to act* gradually came. A series of Parliamentary Acts between 1835 and 1845 led to legislation

3.The fourth obstacle is not dealt with further in this article, other than to say that major reforms to the British basic education system were effected over decades – reforms to the institutions, the training of teachers and to the curricula. As legislated compulsory education took effect, large numbers of new state-supported schools were set up, and teaching became a respected profession.

that enabled the birth of something resembling local government, as we know it today. Of course its development did not stop then – local government still had to acquire many powers, particularly financial powers, but over several decades, this evolved into the needed effective and properly resourced *institutional and administrative machinery*. (For the record, Cape and Natal colonial legislation soon followed the British.)

The 'knowledge of how to act' involves both public health and medical knowledge and engineering knowledge. And of course the 'how' must include not just the conceptual knowledge but also the ability to implement, which includes, for engineering as an example, the institutions, technologies, materials and equipment.

In more than one sense, while the Industrial Revolution caused great social misery, it was also a powerful means of alleviating much of that misery, as follows:

- In the pre-industrial era, water supply was brought into settlements in canals and pipes made of stone in the one case and wood in the other. But making a wooden pipe was a laborious process, besides which the wood had a limited life; also, pumps were primitive, and therefore water in any sizable quantity could only be gravitated to settlements, which implied that sources had to be at higher elevations than the settlements.
- (Skipping over a few generations.) By the early 19th century steam-driven pumping technology could move large quantities of water against gravity. Also, pipe-manufacturing capability, using cast-iron to begin with (later in the century, steel), made possible the conveyance of water in bulk across large distances, and also the reticulation of that water within the settlements – together with other innovations such as household plumbing, which gradually became more or less as we know it today.

On many critical issues, such as the germ-borne causation of disease and its treatment, even by the mid-19th century the foremost 'experts' were sadly ignorant. Often compounding the hampering of improved water, sanitation and health services provision was what we now know to be mistaken perceptions. An important example was the widespread belief that, whatever the medium was that carried cholera, it was not water. Even influential Britons, such as Florence Nightingale, professed that many diseases were borne on 'bad air' (the so-called 'miasma' theory). Before the experiments of Pasteur, Lister and other pioneers, hardly anyone took seriously the notion that diseases could be transmitted by germs.

Cholera was first positively identified as a waterborne disease in 1854 by a London doctor, John Snow. In an early spatial statistical analysis, he showed that the outbreaks in a slum district of London were systemically associated with the water supply from a single pump. But not until some time after this was his opinion generally accepted – it was only in 1883 that the German chemist Robert Koch conclusively established the link between cholera and contaminated water.

Ironically, the industrialisation and engineering advances that, attracted the immigrants through offering prospects of employment, had also both directly and indirectly caused the urban crisis. The industrialisation advanced so much since the start of the 19th century that it was – only now for the first time – possible to undertake on the huge scale required, the major engineering works that would bring fresh water to the cities and take away the wastes. The 19th century, especially the second half, was an era of boundary-pushing civil engineering works such as railways and bridges. But it should not be forgotten that the civil engineering works, that without any doubt had the greatest effect on quality of life, were those related to water and sanitation.

The wastewater specialist whose name ought to be remembered above all others, is the civil engineer Joseph Bazalgette. It was claimed of him that he 'probably did more good, and saved more lives, than any single Victorian public official'.[4] This is quite some claim, when one reflects that this was also the time of Nightingale and Lord Shaftesbury.[5] Bazalgette's major undertaking was responsibility between 1856 and 1889, for motivating and building *from scratch* the main drainage system of Metropolitan London. This drainage system achieved two main direct objectives:

- provided the 'backbone' for a sewer reticulation system which could then be laid throughout the city, enabling all buildings to install flush sanitation; and
- by intercepting the foul waters which had been draining or seeping to the Thames, vastly improved the water quality in the river, allowing it in due course to once again be used for water supply.

Along the way, responsible citizens gradually learned an important lesson which it seems had been forgotten, at least in the sense that it had seldom been taken into account in any planning or implementation. This lesson was that the effects of direct action on some part of the water cycle affect the next part of the cycle, and so on down the line. For example, contamination of a stream at one point has ripple effects downstream, maybe even affecting the water rights of others, or affecting the environment. For another of many possible further examples, deforestation of an area can affect streamflow in a catchment.

Health-related regulation of some sort had existed for centuries – for example mediaeval regulation of slaughterhouses. But it was only in the 19th century that water, sanitation and wastes generally could begin to be regulated in a way which we can recognise today – because giving effect to that regulation was then for the first time becoming possible in terms of the institutions (principally municipal government) and the technology.

4.https://en.wikipedia.org/wiki/Great_Stink#Legacy

5.Shaftesbury was a renowned philanthropist and a leading campaigner for child labour reform and the reform of working conditions in factories.

Finally, ideas continually evolved on means to collect wastewater from settlements and to dispose of it.

The *first* step in this evolution was to remove the wastewater from a settlement – by means of a sewerage system – thus 'reducing, if not eliminating, pollution in build-up areas, and achieving more salubrious conditions in and around habitations generally' (Murray 1987:6).

Once the way was clear to achieving this removal (although implementation might no more than have begun), the *second step* had to be tackled – when the wastewater had been removed, how to dispose of it?

The *third step* was *treating* the effluent – that is, rendering it less harmful *before* it is discharged to rivers, sea or land.

The predominant tendency at first was to discharge the (totally untreated) wastewater into the usually most convenient of the above, namely the rivers. However, as the pollution load on the rivers increased, there grew an awareness that the discharge of sewage, industrial and other wastes into rivers would pollute them to the detriment of the interests of riparian users downstream. Associated with this awareness came a realisation that some forms of treatment (in those days, the term generally used was 'purification') were necessary. In 1868 the British government established the Rivers Pollution Prevention Commission with a brief to investigate methods of wastewater treatment.

Then contemporary advances in understanding of chemical and biological processes aided the research. Initial experiments under the auspices of the Commission focused on mechanical separation and filtration of the wastewater, but the importance of chemistry and biology was soon recognised. Initially, little was known about bacteria and the part played by them in wastewater, but this knowledge soon grew in conjunction with advances in microbiology.

Thus, by the late 1800s, the common methods of disposal were:

- discharge into rivers
- discharge into the sea
- disposal on land (the so-called 'sewage farms').[6]

Specifically in South Africa

From the late 1800s, mining and then industrial development began in South Africa, settlements grew rapidly with migration from within and without the country, the steadily improving infrastructure and medical and health knowledge from overseas really became needed in this country, and institutions and legislation to cope with this change had to be formed and formulated.

For reasons which shall be explained, 1956 is a suitable year at which to separate this narrative into two parts.

In South Africa up to 1956

In much of 19th-century South Africa, particularly the rural areas, significant change was slow in coming to either water supply or sanitation practice. Populations were sufficiently dispersed that disposal of wastes of all forms could take place within a short walking distance of the households, with very little chance of harming anyone else – thus no need for any kind of regulation. In the new settlements which sprang up under the aegis of Boer or British authorities, there was initially little need for regulation – practices deemed potentially harmful in some way were few and were usually self-regulated or regulated by community consent.

Thus Cape Town, supplementing the neglected canals (grachts)[7] installed by the Dutch administrations, by 1834 had 36 free-flowing fountains. However these were perceived to waste the water, so they were replaced by 'Swaai' pumps, whose back-and-forth action required effort – and therefore users were less inclined to waste.[8] In the City Bowl these were fed either from groundwater or with supply piped from springs, for example, the Breda Springs in Oranjezicht. Over the years, as population grew steadily, these were supplemented by water caught on and conveyed from Table Mountain. Water security was always to some or another extent directly dependent upon the rainfall patterns. Thus there were water shortages, and rationing and supply interruptions, from time to time.

Until the discovery of diamonds (from 1866) and gold (foundation of Johannesburg 1886), towns grew slowly. In these new rapidly growing mining towns technology introduced in Europe usually made its appearance quite soon. Of the new post-1880 inland settlements, Johannesburg and its sister gold mining towns had major water problems from the start. In a sense, nature had not been kind by providing the rich gold-bearing reefs within a couple of kilometres of a major watershed – therefore such streams as existed were small and non-perennial. There are reports of water being sold by the bucket – at a price of two shillings and sixpence (an immense amount of money for those days) per bucket! This, of course, kept personal consumption at extremely low levels until the first of the engineered schemes, early in the 20th century, to bring water from more distant places.

6. This article is not the appropriate place for a discourse on wastewater treatment methods or on the results of works not functioning effectively. Suffice to say that a treatment works using up-to-date infrastructure and treatment methods, and properly staffed and run, is capable of consistently producing an effluent which matches or exceeds the works-specific parameters laid down by in the works' licence conditions by the regulatory authority (in South Africa, the national Department of Water and Sanitation (DWS)).

Unfortunately, many works are not operated effectively, are understaffed, have insufficient capacity (especially, but not only, in the rainy season – thanks to infiltration into sewers upstream), are ageing – and so on. The result then is effluent which does not meet licence conditions. This of course has many negative effects for users downstream. (The topic is well documented: for example as is neatly summarised by Oberholster, Ashton, Du Preez and Oelofse (in CSIR 2010). But the effects of neglect continue right up to the present time, for example: http://www.engineeringnews.co.za/article/municipalities-to-blame-for-contamination-of-vaal-river-system-parliament-2018-08-20)

7. The Cape Town canals, still in use for household water purposes during the 18th century, had by the 19th century gradually ceased to be used for that purpose, thanks to their increasing levels of contamination. (The effect of van Riebeeck's placaat, and subsequent attempts to keep the stream and canal water clean, clearly having worn off over the decades!)

8. For many years, the sole survivor has been the 'Hurling Swaai' pump in Prince Street, Oranjezicht.

Turning again to wastewater, as early as 1902 the Cape Peninsula Commission was able to report that 'nearly all' of the houses in the centre of Cape Town were connected to a waterborne sewerage system (Cape Colony 1902), whereas houses in the suburbs were not:

> While by 1915, the suburbs of Woodstock, Maitland, Mowbray, Rondebosch and Claremont were served with a more stable water supply from the Newlands Storage Reservoir, with respect to sewerage [*sic*] removal, little had changed since 1895. Thus the districts of Woodstock, Maitland, Mowbray, Rondebosch and Claremont continued to be served via a pail system – the stercus being removed on a weekly basis. In Woodstock and Maitland moreover, there being no system of surface drainage, slop water was allowed to pass into the street gutter or on to adjacent land, and ultimately to find its way into neighbouring streams – in the other suburbs, the 'very dirty slop water' was collected in pails or tubs and emptied every day except Sunday, whilst other water and bath water was treated in the same fashion as in Woodstock and Maitland. It was a most unsatisfactory situation. (Buirski 1983:132)
>
> Prior to the installation of a sewerage system, 'night-soil' buckets were conveyed by train nightly to a depositing site at Bellville. In 1895 W.T. Olive, a consulting engineer, was commissioned to design a sewerage system for Cape Town. Almost co-incidentally the Green Point and Sea Point Municipality introduced a waterborne sewage system which provided for final discharge[9] into the sea. (Murray 1987:27)

Cape Town was not unique:

> The pit privy and bucket was the norm in Pietermaritzburg before 1905, and household waste liquid was merely discharged into open street channels and drains for discharge to the Msunduzi River. (Osborn 1988:139)

The first municipal wastewater treatment works placed in commission in South Africa – by today's standards, extremely small and using primitive technology – commenced operations in Bloemfontein (November 1904) and at Wynberg (January 1905), followed by Pietermaritzburg (1908). In these cases, the improved resultant effluent was irrigated over adjacent land. In all other urban centres wastewater, if it was collected at all, was irrigated on land in a still untreated state.

For the first half of the 20th century, land irrigation continued to be the main means of wastewater disposal:

> The Union Health Act No. 36 of 1919 strengthened this situation, as it prohibited local authorities from discharging effluents into a river, irrespective of the quality … This legislation also permitted the Minister of Health to lay down standards for purified effluents, but these powers were never exercised. In 1951 the South African Bureau for Standards also published standards for the discharge of effluent to streams, but these were more in the form of a guide and there was no compulsion to enforce them. (Osborn 1988:139–141)

Nonetheless, there was some regulation, in particular, that the national Department of Health laid down the area of land to be available for discharge – for example, not less than 100 acres of 'suitable ploughable land' for every million gallons treated per day (Murray 1991:27).

It was soon realised that seepage to groundwater and watercourses was likely to occur where land was irrigated, and so the Department of Health prescribed increased minimum areas of land for different qualities of effluent. However, events began to overtake this, principally in the form of the establishment of new industries with new substances in their effluents. Realising the need, cities and larger towns built works where the wastewater could be treated before being irrigated. The pioneers included Stellenbosch, Cape Town, Kimberley, Queenstown, Johannesburg and Pretoria. As a result of innovations from overseas, but coupled with local experimentation and monitoring particularly in Johannesburg, the technology used was often the most modern available worldwide (Grant & Flinn 1992:63–69).

Nonetheless, before 1956, in terms of South African legislation (and consequent regulation), wastewater, even if treated, could not be discharged directly into watercourses, but could only be disposed of on land or out to sea. (Some exceptions permitted, usually but not always temporarily,[10] notwithstanding.)

Enforcement of effluent quality regulations was never that strict or effective, principally because (examples only):

- Populations were lower than today (South Africa: in 1911, 6.0 million people; 1936, 9.6; 1960, 16.0; 1996, 40.6; 2018 around 56). Current comment:
  - The effect of this population growth on water and sanitation has been enormous. For one thing, the open space, the environment 'out there', which could be the dumping ground for all manner of wastes,[11] has effectively disappeared.)
- Together with higher populations has come a disproportionately very much higher demand for water and sanitation services. Current comment: For example:
  - The type of household that in the past might have been satisfied with one outside tap, would now have taps inside and outside the house, together with several water-using appliances.
- Wastewater constituents were generally less complex than today. Current comment: For example:
  - 'New' chemicals from the petrochemical and pharmaceutical industries … These chemicals enter the environment through, for example: pesticide applications, as byproducts of industrial processes, and household waste such as cleansers and pharmaceuticals (Du Preez 2010:17).

9. Of untreated effluent.

10. In 1909, the Governor of the Transvaal granted permission for the Pretoria City Council to discharge purified effluent directly into the Apies River. This enabled the Daspoort Wastewater Treatment Works to be built. (As an aside: commissioned in 1912, the main structures of the biofilters then installed are still in use to this day, although these biofilters now account for a minuscule part of treatment capacity.)

11. Dumping of waste beyond the urban fringe was very seldom wilful damage. Usually, disposing in this manner was chosen because it presented the financially cheapest solution. Nonetheless there was often great faith in the healing power of the natural environment – for example the long-held belief that contaminated water flowing over seven stones would be cleaned.

- Less was understood about the often pervasive effects of certain contaminants and causative chains.
- There was much less awareness of the natural environment and of the threats to it, if only because of the far lower populations than today, and their lesser mobility (100 years ago, very few people possessed motorcars, and roads other than in city centres were bad or non-existent).

However, 1956 saw radical change.

In South Africa after 1956

As a result of both:

- awareness of increasing populations, complexity of wastewater and environmental concerns – and anticipating further population growth and urbanisation
- development, both in South Africa and overseas, of treatment technology …
- … in 1956, a new *Water Act* brought radical change to how wastewater was viewed.

The most immediate and striking change was a prohibition of irrigation of effluent onto land. Discharging effluent into watercourses (rivers and streams, or in the case of coastal areas, into the sea) became the only legal option.

Together with this (among many other things), the 1956 Act brought promise of:

- a complete revamp of the regulatory environment (in respect of not only wastewater effluent, but in many other related areas)
- a promise of more formally organised and much stricter enforcement.

The *Water Act* No. 54 of 1956 'basically reversed' the prohibition on discharging effluents into a river, …

> and made it obligatory to discharge purified effluents to the watercourse. Permits were required to use water for agricultural purposes and to discharge effluents not complying with the quality standards. These were finally published in Government Notices over the period from 1962 to 1984. (Osborn 1988:141)

The concept was introduced of differentiating, according to the use to which the 'receiving waters' (the term used) are being put, the standards required of effluent to be discharged into watercourses. In brief, and to illustrate by two extreme situations:

- discharge into relatively undisturbed watercourses from which communities draw water, and which are also used for activities such as swimming, has to be to the highest standard
- discharge into already heavily polluted watercourses can be at a much lower standard.[12]

The concept of 'General Standards', 'General Authorisations', 'Special Standards' and 'Special Authorisations' for wastewater effluent quality was refined subsequent to the 1956 Act.[13,14] In brief, General Standards, which are lower, apply to effluent discharge everywhere that Special Standards are not specifically required. Special Standards are:

> quality standards for wastewater or effluent arising in the catchment area draining water to any river specified in [a Schedule] or a tributary thereof at any place between the source thereof and the point mentioned in the Schedule, insofar as such catchment area is situated within the territory of the Republic of South Africa. (DWAF 1984:1)

These quality standards have been raised from time to time over the years. For example:

> The oxidation pond system situated south of Zeekoevlei served the City [of Cape Town] for many years. [However] the more stringent requirements set in recent years by the central governments Department of Water Affairs for effluent quality made these ponds unacceptable and they thus had to be replaced. (Cape Town 1980:13)

The Preamble to the *National Water Act* of 1998 (No. 36 of 1998) – which, at least as far as wastewater effluent quality matters are concerned, updated and strengthened the philosophy of the 1956 Act – commences as follows: 'Recognising that water is a scarce and unevenly distributed national resource which occurs in many different forms which are all part of a unitary, inter-dependent cycle …', the Act puts the national minister in charge as the state's custodian of this public resource 'to ensure that water is allocated equitably and used beneficially in the public interest while promoting environmental values'.

In particular, in this Act:

- Chapter 3 'Protection of Water Resources' inter alia classifies water resources and resource quality objectives; and
- Chapter 4: 'Use of Water' *inter alia* sets out the considerations, conditions and essential requirements of general authorisations and licenses.

The same year DWAF brought out 'Revision of General Authorisations in Terms of Section 39 of the National Water Act, 1998'.[15] This took further the determinations of, inter alia:

- 'Wastewater limit values applicable to the irrigation of any land or property' (limits set in terms of parameters such as suspended solids, chlorine as free chlorine, Chemical Oxygen Demand, faecal coliforms and fluoride).
- The records of monitoring the quantity and quality of the wastewater used for irrigation.
- 'Wastewater limit values applicable to discharge of wastewater into a water resource' (set in terms of similar – but not exactly the same – parameters as above).

12. Some irony: situations where the quality of a stream below the discharge point of a wastewater treatment works is higher than that above it, thanks to the diluting effect of the treated effluent on the heavily polluted stream upstream, are by no means uncommon. For example: for many years the Klipspruit through Soweto was relatively cleaner below the Olifantsvlei Wastewater Treatment Works than above it.

13. 'Refined', not introduced. A basic form had been introduced in earlier legislation.

14. Initially in terms of Government Notice No 555 of 1962, promulgated in terms of Section 21 of the 1956 Act.

15. This has gone through several revisions, each entailing either greater control or raised requirements or both. For example: Government Notice 665 in Government Gazette 36820, 6 September 2013 (South Africa 2013).

Source: Photo taken by Kevin Wall

FIGURE 3: What final effluent from a wastewater treatment works *should* look like.

- 'Listed water resources' (mostly defined lengths of streams, but also including RAMSAR[16] listed wetlands) – in respect of these areas, Special Standards apply.

Of course, the effect of all this legislation and these regulations can only be as good as the combination of:[17]

- the attempts of water services institutions to comply with regulation
- the monitoring, regulation and enforcement.

Suffice to say:

- A number of agencies and individuals are conscientious, and do their best to meet the required standards. But all are juggling to provide services and meet a range of regulatory requirements, doing this on budgets which are usually too small for the task. From time to time therefore, despite the will to keep within the limits, even the best of them is unable to do so.
- Other agencies and individuals seem not to care, or have given up trying.

Enforcement of the regulations ought to address this, but very seldom does effectively (Figure 3).

16.The Convention on Wetlands: https://www.ramsar.org

17.Dubbed by the present author the 'compliance and regulatory gap' (Wall 2005).

In brief, the enforcement of wastewater effluent quality regulations in South Africa is, with few exceptions, hamstrung by budgets that are far too small. This with little doubt can be ascribed to the lack of capacity and will on the part of particularly, the Department of Water and Sanitation (DWS – the renamed DWAF) and the Department of Environmental Affairs. (From time to time allegations also surface of other factors related to staff attitudes and competence.)

The frustration facing the conscientious agencies and officials may be summarised as follows (using regulation of wastewater discharge – not from wastewater treatment works, but from industrial premises – as an example):

- Too few posts are created in the establishment (e.g. a city at one stage had only six posts of inspectors – this to cover the city 24/7!).
- Moreover (same city) two posts had been frozen.
- There are too few monitoring points on the watercourses (and in the storm water drainage system, which must also be monitored for industrial waste – discharge of which to a storm water system is illegal).
- If pollution is noticed, the way in which the regulations are generally interpreted by magistrates is to require that, if anyone is to be prosecuted, the source of pollution be proven beyond reasonable doubt.
- At least one inspector must therefore spend a large part of his or her time over the next few months working with the municipal legal advisers to prepare a case.

Source: Photo taken by Kevin Wall

FIGURE 4: Discharge of industrial waste into a storm water canal – in broad daylight!

- The inspector must appear in court while the case is heard, and be prepared to give evidence and be cross-examined.
- The prospect then is that the magistrate may not understand the technicalities or is badly advised by his technical assessors (if any), and the case is dismissed. Or the perpetrator is fined – but the maximum fine is a derisory amount which to the perpetrator is no deterrent whatsoever (Figure 4).

As a retired former senior official stated, quoting his own experience when at DWAF (to paraphrase):

> I had prepared the Department's case most carefully, then briefed our attorney. But the other side hired the smartest Senior Counsel in the field – he proceeded, over two days, to trash both the regulations and our evidence. Even a magistrate heavily biased in our favour, when confronted by this spellbinding performance, could not fail to have pronounced that the defendant must be acquitted on the grounds of inconclusive evidence. …
>
> … It was a long time before we felt bold enough to attempt another prosecution (pers. comm., name withheld – 2018).

Note that municipalities and any other institutions (including private institutions, state-owned enterprises and other government departments[18]) cannot operate a wastewater treatment works without a licence from DWS. Regulations require the registration of every 'works' and every 'process controller' (a defined qualification – these are the officials in charge of works) 'on that waterwork'.

These regulations have been changed from time to time (usually the requirements are made more stringent), but are always specified in terms of:

- the population served
- the infrastructure and its characteristics (e.g. design capacity, peak flows, power installation)
- operating procedures (e.g. raw influent flow rate, chemical dosing, stabilisation, disinfection)
- control processes (e.g. water losses, pumping, maintenance, laboratory services)
- 'special processes' (e.g. fluoridation, reverse osmosis, activated carbon – if any are used)
- sensitivity of water resource into which treated water is discharged.

The regulations then set out the measurable parameters which must be met in terms of the above.

But, in addition, 'points' are awarded on the basis of the above-listed parameters, and DWS then classifies each works on a scale from A (larger quantities, more complex processes, greater sensitivity of waters discharged into) through E (smaller quantities, etc.). That classification is then used to determine the educational qualifications and other skills

18. For example Department of Correctional Services, which is the owner of several dozens of small wastewater treatment works.

requirements of the process controllers. For example, 'Schedule 4: Minimum class of process controller required per shift, and supervision …' requirements. In terms of this Schedule, the lowest scale of 'works class', namely E, must have a Class I operator per shift, under overall supervision[19] of the works of a Class V supervisor, whereas the highest scale, namely A, must have a Class IV operator per shift under a Class V supervisor (DWAF 2005).

A dilemma very often – too often – facing DWS arises when a treatment works does not meet the licence requirements. What is DWS to do? Close the works down? Obviously it cannot because the quality of the effluent from a work which is operating, even if not operating very well, is inevitably much better than the quality of the effluent from a work which is not being operated at all, but is flowing straight through without any treatment.

Finally on wastewater, monitoring for the purposes of regulation can serve purposes other than compliance checking. New analysis techniques suggest that monitoring of influent to and effluent from wastewater treatment works can identify certain health and social risks much quicker, with more certainty and much cheaper, than the public health system, which relies upon reporting from hospitals and clinics, is able to. Wolfaardt described the extent to which treatment works monitoring methods already available, can identify within 24 h the extent to which specific drugs are being used in specific catchment areas. Salient detail can also be provided – for example, with what other substances this drug-taking is associated, for example, alcohol. Similar techniques are able within hours to identify selected characteristics of the use of medical substances, for example, antiretrovirals (Archer et al. 2018; Wolfaardt 2018).

Wolfaardt also described the fast-increasing range of chemical substances found in wastewater, many of them in pharmaceutical and personal care products, and the increasing use of indicators to track them – also the research into ways in which these substances might be neutralised at wastewater treatment works (Archer et al. 2018; Wolfaardt 2018).

Summary and conclusions

Authorities and users in South Africa have, over a long period of development overseas and locally, gained extensive experience of strategies for the effective regulation of wastewater. That said, and as briefly as possible:

- Population growth, spatial patterns (particularly urbanisation) and the demand for goods and services inevitably exercise the biggest influence on wastewater effluent volume and also on its quality.
- The second biggest influence is legislation and the regulations promulgated in terms of that legislation – but only if the regulations are effectively enforced. Legislation will make little difference without regulations; regulations will make little difference without enforcement.
- In efforts to improve effluent quality, no one size fits all.
- Sometimes, reform has to overcome ignorance and prejudice.[20]
- Reform often advances by a 'virtual spiral'. For example: technology invention or adaptation might not be adopted until the need for it is accepted, and there is the will to install it.[21] At other times, the need is identified ahead of the technology to address it – thus there would be a period while possible technologies are developed or mass-produced at an acceptable price.

How effective any of these are depends on many factors, principally:

- the national and local context, including tradition of regulation and of voluntary contributions; and
- the current and past national and local situation, including where a society has come from, its norms and standards, and its expectations.

So, to sum it all up – what generally can be said about the track record of these many and varied effluent quality regulations?

The bottom line is while the general themes of wastewater effluent regulation have not changed in a century, their context has radically changed, and almost everything else about them has changed. In brief:

- Because of population growth, and factors associated with population growth, the context of, for just a few examples, demand (for water, and for a cleaner environment [particularly, in the current instance, the quality of surface water courses]) has increased at a much faster rate than has population growth itself.
- At the same time, the opportunities for tapping new water resources have diminished and become much more expensive, particularly because the nearer and cheaper resources have already been exploited, and new sources are inevitably more expensive.
- Available treatment technologies have multiplied, but only a small minority have proved to be of lasting value. Nonetheless, the technologies commonly used, to implement improvement and to monitor it, have in general vastly improved.
- There is no doubt that, in all societies, the understanding of the link between water and wastewater and health – and the economy – has improved – in some societies more than others.
- There is today far more awareness of and concern for the needs of the natural environment, but the extent to which this is translated into action varies enormously.
- Water and sanitation issues have become far more political than before, and bound with considerations of social reform. More and more, also, water and sanitation have taken account of access and equity.

19.The supervisor:
Does not have to be at the works at all times but must be available at all times. If the owner of a water work has no person of this class, a contractor or consultant with the required qualifications shall be appointed to visit the work weekly. (Ibid.)

20.E.g. once cholera had been identified as a waterborne disease, in 19th-century Western Europe ignorance and prejudice had to be overcome before there could be widespread adoption of the means to conquer cholera's effects. (This same lesson – the need to overcome ignorance and prejudice – has had to be learned by other societies over and over again since.)

21.Technological and other developments have sometimes been referred to as 'ahead of their time'.

Change has been far-reaching – although not radical enough for some. Responses have often been 'too little' and 'late', but, thus far, seldom 'too late'.

Some things have not changed – for example, the necessity for political will to prepare adequately for the future, and to fund what is and will become necessary. And a lesson repeatedly, not adequately, learned is that the passing of legislation is only the first step in a process of enforcing change. After legislation must come regulation, and after that enforcement. But it is enforcement which is so often weak and ineffective – truly, the weak link in the chain.

Points to take away

For wastewater effluent regulation to succeed in its purpose:

- Although legislation and regulation are not the weak link, enforcement is, and therefore this must be tightened:
  - the political will to achieve this is needed: particularly to improve monitoring and enforcement capacity, and to increase the penalties and raise the rate of prosecutions.
- In the face of increasing source, variety and complexity of contaminants, methods to cope with these must continue to be evolved.

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