OVERVIEW

WATER SUPPLY AND PUBLIC HEALTH

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ABSTRACT

This article deals with the link between water supply and community health. This link, often thought to be a direct and simple one, is multi-faceted and complex. Water of better quality does bring certain benefits, and water in higher quantity brings other benefits. Community health, however, is also influenced by a multitude of other factors. A good water supply, therefore, is a necessary but not sufficient condition for good community health.

A successful water supply system, in turn, requires a number of equally important elements. Selection of the best source, proper treatment, adequate water quantity, well managed distribution systems and protected storage containers all contribute to safe drinking water. In many cases in South Africa, where water is supplied at communal taps a distance away from the consumer's homes, the manual haulage and storage between tap and consumer proved to be an especially critical and vulnerable part of the supply route.

South Africa has a tremendous backlog in water supply infrastructure, which is currently aggressively addressed through numerous projects under the Reconstruction and Development Plan (RDP). Although the current minimum water supply standards may be disappointing in terms of sophisticated first-world systems, they do strike a realistic compromise between what can be practically achieved, and what would improve the quality of life for millions of south africans. The article is concluded with a summary of general planning principles which have been shown to contribute to the success of water supply projects elsewhere in the world.

OPSOMMING

Die verband tussen watervoorsiening aan die een kant, en gemeenskapsgesondheid aan die ander kant, is nie so 'n direkte en eenvoudige verband as wat algemeen aanvaar word nie. Hierdie artikel het dit ten doel om die veelvuldige fasette van hierdie verband uit te wys, en om aan te toon dat watervoorsiening maar een van 'n aantal voorwaardes is wat bevredig moet word alvorens 'n verbetering in gemeenskapsgesondheid verwag kan word.

'n Suksesvolle watervoorsieningstelsel, op sy beurt bestaan uit 'n reeks skakels wat almal ewe belangrik is. Die keuse van 'n geskikte bron, deeglike suiwering, genoegsame hoeveelhede water, goed bestuurde verspreidingstelsels, en behoorlik beskermde opgaarreserviors is almal deel daarvan. In groot dele van Suid-Afrika, waar water by gemeenskaplike staankrane voorsien word, blyk dit dat die laaste gedeelte vandie drinkwaterroete - van die kraan tot in die huis - veral 'n kwesbare en onbevredigende gedeelte daarvan is.

Suid-Afrika is tans besig om die geweldige agterstand in watervoorsiening op groot skaal te probeer uitwis deur middel van vele projekte as deel van die Heropbou- en Ontwikkelingsprogram (HOP). Alhoewel die huidige minimum drinkwaterstandaarde steeds laag is in verhouding met die standaarde in byvoorbeeld ons groot stede, verteenwoordig dit 'n realistiese kompromis tussen wat prakties haalbaar is, en wat steeds 'n groot verbetering in die lewenskwaliteit van miljoene Suid-Afrikaners sal teweeg bring. Die artikel sluit af met 'n opsomming van suksesvolle beplanningstelsels wat hulself reeds in verskeie dele van die wêreld bewys het.

INTRODUCTION

The provision of adequate, safe drinking water to all people is one of the high priority goals in the new South Africa, and is currently being actively and aggressively pursued through numerous projects under the Reconstruction and Development Programme. The benefits of an ample water supply point close, or in one's home, are obvious in terms of convenience, more free time previously spent on hauling water, and the ability to make use of water-borne sewage. More important than these immediate benefits, hopefully, is a concomitant improvement in public health. This link, however, is not at simple or direct link, and often the expected public health improvement does not materialise to the extent anticipated.

Water is implicated in public health in a number of ways. This is best illustrated by the following simple, but useful classification:

Waterborne diseases, such as diarrhoea, are spread through direct ingestion of contaminated water. Their incidence can be reduced by the *treatment* of the water.

Water-washed diseases, such as trachoma, are spread through insufficient water for proper personal hygiene. Their incidence can be reduced by providing *more* water.

Water-based diseases, such as schistosomiasis, are those diseases caused by pathogens which spend part of their life cycle in water. Their incidence can only be reduced by avoiding *contact* with natural rivers or impounded water.

Water-related diseases, such as malaria, are caused by insect vectors which require stagnant water. Their incidence can only be reduced by *eliminating* stagnant pols or puddles of practical, or spraying programmes, where - for example - the water surface is covered with a thin film of diesoline.

Water supply can reduce the incidence of the first two categories by providing safer or more water. It will have very little effect on the last two categories, which are functions of the natural water environment.

The objectives of this article are:

- To discuss the connection between water quality and public health,
- To demonstrate the importance of water quantity, and to investigate the factors that influence water demand,
- To review the current status of water supply in South Africa.

PERCEIVED BENEFITS OF WATER SUPPLY

The traditional view is that proper water supply will lead to a reduction in water-borne diseases through the producing 'better' and 'safer' water. It is necessary to point out that this could very well be a gross oversimplification.

Water supply is only one, albeit important, determinant of public health. Food hygiene, public health education, personal hygiene, sanitation, health care, *et cetera*, are all important prerequisites for a health population. While water supply usually has important benefits, it is, by itself, no guarantee that public health will improve. There are other methods for improving public health, which, under certain circumstances, might be even more effective. One example of a method to reduce the mortality rate due to diarrhoea, is oral rehydration therapy, which will cost only one hundredth to one tenth of the cost of traditional water supply (Gibbs, 1987:43). Another example would be diarrhoea prevention measures focused specifically at day-care centres, which were shown to have a much higher effect on diarrhoea than the quality of the water supply, according to a recent study in the Western Cape (Genthe *et al.*, 1996).

On the other hand, water supply will also bring more than just better water quality. It has been argued (Cairncross, 1987:30) that the first and foremost benefit of a water supply is the fact that it can provide more water to a household. (The link between the distance form the supply and the demand is explored further on in this paper.) The second additional benefit is the fact that it creates more free time and energy for the women of a developing community. This time if often spent on chores like sweeping, washing and cooking which provided added health benefits.

Although the rest of the article will be restricted to the benefits of water quality and water quantity, it is clear from the above the a safe water supply is a necessary, but insufficient condition for public health. It always has to be considered in conjunction with other equally important public health determinants.

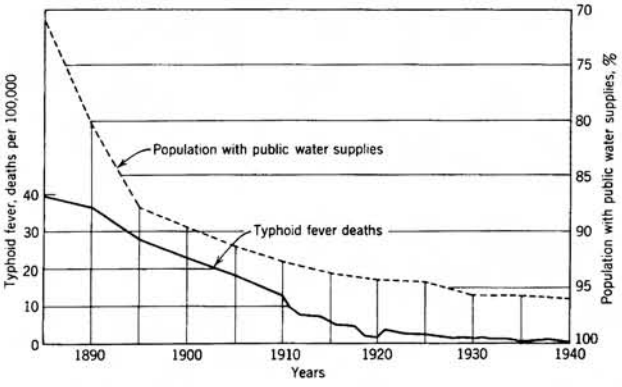
THE IMPORTANCE OF WATER QUALITY

Much of the principles of modern water treatment was established during the 19th century in Europe and England. The engineers of that time, before the breakthroughs in bacteriological understanding of the late19th century, established these principles through keen observation of a number of dreadful epidemics. This was the time after large numbers of people started to amass in cities, and when water-borne sewerage systems were being built to prevent the unbearable conditions caused by the accumulation of filth and excreta.

The first principle established was that of *source selection*. The selection of the best water source in the vicinity will go a long way towards the reduction of water-borne diseases. A classical example is

London in 1854, where 600 deaths from cholera were registered. At that time, the water abstraction points in the Thames were in the same vicinity as the sewer outfall, which discharged raw sewage into the Thames. There were two water companies, each supplying a separate area of London. In 1849, when both companies took their water from the same sewage-polluted pool, both areas were equally affected by cholera. Statistics from 1854, when one of the companies moved its intake to an unpolluted reach upstream of the sewer outfall, clearly showed a dramatic decline in cholera cases from its supply area (Institute of Water Engineers, 1950:chapter 15).

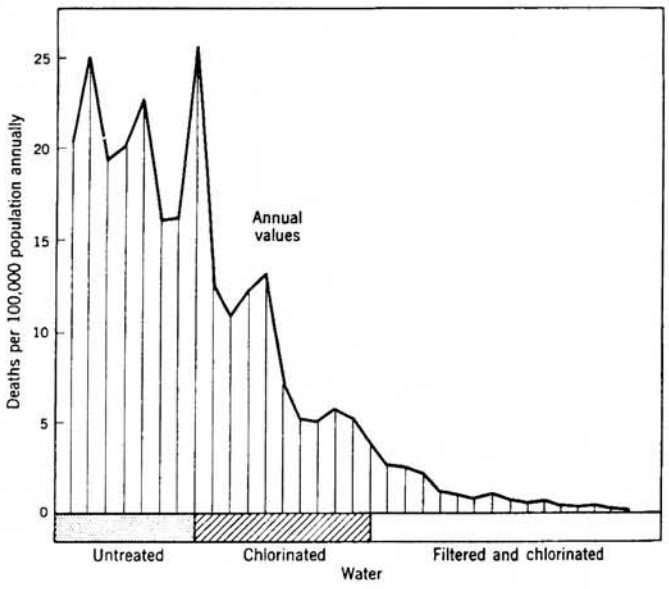
Individual households have little option but to utilize the closest water source. Only when communities work together to develop a common public water supply, are they in a position to select a further, but better source in terms of water quality. That this is indeed the case, and that it does have and effect on public health, is illustrated in Figure 1.



(Figure 1) *Example of the benefit of public water supplies, as evidenced by the reduction of typhoid fever deaths in Massachusetts from 1885 to 1940.* (Fair *et al.*, 1968:chapter 19)

The second water supply principle established was that of *treatment*. Unless a source is unusually pure or well protected, some form of treatment will be required to guarantee quality. The well-known case of Hamburg and the adjacent township Altona in Germany is often quoted as support of mentioned principle. These two areas had similar, but individual raw water intake from the river Elbe. The water to Altona was filtered with slow sand filtration, the water to Hamburg not. During 1892, Hamburg suffered an outbreak of cholera which affected 18000 people and left 8000 dead, while neighbouring Altona escaped (Institute of Water Engineers, 1950).

The two principal water treatment processes, from a public health point of view, are filtration (which can remove particulates down to 1 µm) and chlorination (which will effectively inactivate viruses and bacteria). To show how these processes contributed to a public health improvement, an example is given in Figure 2.

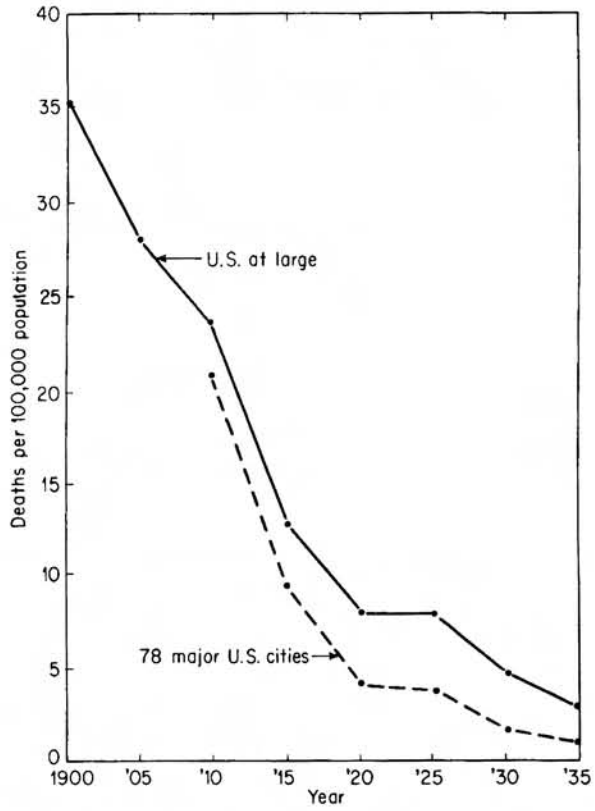


(Figure 2) *Example of the benefit of water treatment, as evidenced by the reduction of typhoid fever deaths in Detroit, Michigan, supplied from clear lake.* (Fair *et al.*, 1968:chapter 19)

The third principle to be established was that of *protected storage* of drinking water. After treatment, water should be protected from recontamination. A striking example from 1933 is quoted: An outbreak of dysentery (eventually traced to a leaking sewer passing directly over an open storage tank) occurred attwo large hotels in Chicago. 1409 cases of dysentery and 98 deaths were reported. This case was certainly no exception. For the period 1938-45, no less than 42% of all disease cases attributable to public water supplies were due to contamination of the distribution system (Institute of Water Engineers, 1950).

The fourth principle established was that of *proper management and control*. The best water supply system can only work satisfactorily if it is diligently attended to and operated with the necessary skill and care. Typhoid outbreaks in Lincoln (1904) and Croydon (1937) provide a number of examples of careless operation which led to disaster. Workmen, amongst whom was a carrier, were not medically examined, protective clothing and boots were not properly cleaned, chlorination was not performed continuously, water mains passed through sewer manholes, and the sanitation arrangements at the treatment plants were unsatisfactory (Institute of Water Engineers, 1950).

This points to the advantage of having larger water supplies, rather that a multitude of smaller ones. Small communities have limited personnel and skills to maintain the desired level of operation, whilst larger utilities and water boards have the resources and dedication to manage and operate their treatment plants effectively. Figure 3 clearly shows the results of the better treatment, control and management evident in larger cities.



(Figure 3) *Example of the better operation and control at larger treatment plants, as evidenced by typhoid and paratyphoid death rates in the USA.* (Sawyer & McCarty, 1967:365)

In advanced societies such as Britain, Europe and the USA, from which the above cases and statistics were quoted, the occurrence of severe water-borne diseases, such as cholera and typhoid, is generally used as public health indicators. How important are these diseases in developing communities such as South Africa? Table 1 shows the death rates for Sri Lanka; a situation more typical of what can be expected locally.

Table 1. Deaths per 100 000 population for selected causes in Sri Lanka in 1957. (Fair *et al.*, 1968:chapter 19)

DISEASE	DEATHS PER 100000
Gastroenteritis & colitis	46,7
Helminth diseases	42,8
Dysentery	8,4
Typhoid fever	2,7
Infectious hepatitis	2,0

* excluding diarrhoea of the newborn

Table 1 shows that typhoid fever (the indicator used in Figure 1-3) was a relatively minor cause of death, compared to other diseases. There is reason to believe, however, that the same water quality benefits, quoted above, will hold true for local conditions, as the major diseases are strongly implicated with the quality of the water supply.

MAINTAINING WATER QUALITY UP TO THE CONSUMER

Good water quality can only be guaranteed through properly designed and controlled water treatment. A great deal of emphasis had therefore been placed on treatment and bulk water supply, and perhaps less on the *maintenance* of water quality as the water is distributed or conveyed to the final consumer. It is becoming more apparent that water quality can, and will, deteriorate after treatment unless special attention is paid to the equally critical water distribution that follows water treatment.

In developing countries such as South Africa, this problem is compounded by the fact that the piped water supply often does not end in the home of the consumer, but stops at a communal water point or standpipe, a distance away from the consumer's home. The final step of hauling the water to the home, as well as the storage of the water in the home, mostly in open or dirty containers, provide numerous opportunities for recontamination of the water. That this is indeed the case, will be demonstrated by three case studies from Southern Africa.

The first case was reported from Lesotho (Mathebula, 1987:38), where a suburb of the capital city Maseru suffered a high incidence of childhood diarrhoea, despite it being served with a clean water supply and a well functioning pit latrine sanitation system. The area is supplied with standpipes, at about 20 households per tap, water collecting trips were short and the demand was correspondingly, relatively high. The water from the standpipes was found to be safe, but many samples taken from storage buckets in the homes were subject to faecal pollution. The conclusions drawn from this experience were that water supply and sanitation have to be complemented with a greater emphasis on household hygienic practices, such as keeping the home yard clean from faeces, training children in the proper use of the latrine, and washing hands after using the latrine or before preparing and handling food.

The second example is reported from the Western Cape (Genthe *et al.*, 1996), where diarrhoea was also used as an health indicator. A case-control methodology was used, with about 300 cases and controls in a community where water was supplied to communal standpipes. Water supplied to the supply points was of good microbiological quality and complied with specifications. Water sampled from in-house water containers, on the other hand, deteriorated significantly after storage, so that less than 70% of samples complied with specifications. No differences, however, in the quality of supply were found between the diarrhoea

cases and the controls, indicating that the water was not the sole source of contamination.

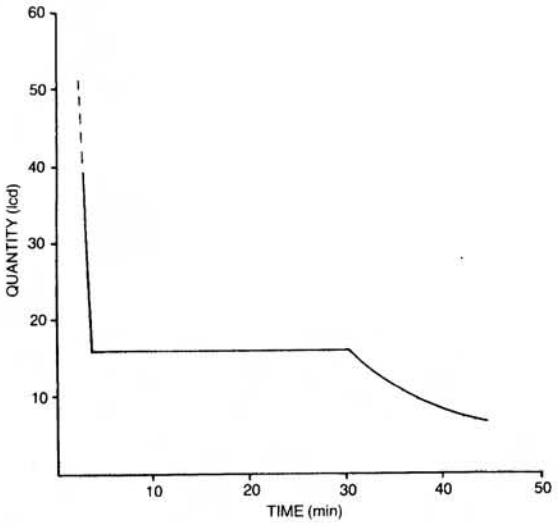
Other factors which were implicated, were attendance of crèches, and poor household practices. The researchers, in conclusion, highlighted the need for health education, especially for child care facilities.

The third example is cited from a large developing urban settlement in the Central Free State (Williams *et al.*, 1996), where diarrhoea was implicated as the main reason for the high mortality rate. This community is also served with standpipes in the streets and in yards, and water is stored in various containers in the households. As in the previous cases, the water supplied at the taps was of acceptable quality, but the water sampled from the household containers was recontaminated beyond acceptable levels, for both diarrhoea cases and controls. In this case, the containers used in the homes of diarrhoea cases were dirtier than those of the controls, but the relatively small sample size (74 cases and 26 controls) did not facilitate statistical verification. However, indications were clear that methods of hauling and storing water were more likely to contribute to diarrhoea, rather than the water supplied through the supply network.

THE IMPORTANCE OF WATER QUANTITY

The quality of water is obviously of overriding importance when water is directly ingested. Water has, however, many other uses which also affect public health. This was succinctly put by Cairncross (1987:30): *"For many of the world's poor, the first health requirement is not for cleaner water but for more water, whatever its quality, to wash thing and keep them clean"*.

The quantity of water consumed, intuitively, depends on the time or effort spent to obtain the water. This dependence was quantified by Cairncross (1987:30) and is reproduced in Figure 4.



(Figure 4) *Graph relating the domestic water consumption to total collection time, with the height graph (i.e. the absolute water quantity) dependent on local conditions.* (Cairncross, 1987:30)

When water is far away (further than 30 minutes), there is a gradual dependence of quantity on distance; the further the water, the less the consumption. At a distance less than 30 minutes (about one kilometre), the water consumption reaches a plateau where consumption is independent of distance. At much shorter distances (typically in the yard or house), the consumption rises steeply.

What is the increased water consumption used for? A comparison was made between two similar villages in Mozambique (Cairncross, 1987:30) where water collection took 15 minutes in one case, but 5 hours in the other. The breakdown of water consumption is shown in Table 2.

Table 2. Mean daily water use (litre/capita/day) in two Mozambican villages.
(Cairncross, 1987:30)

Village	**Village A**		**Village B**	
Watercollection time	**5 hours**		**15 minutes**	
Drinking	0,21	6%	0,36	3%
Cooking	0,67	21%	1,93	16%
Washing	0,50	15%	1,36	11%
Bathing	0,80	25%	4,75	39%
Bathing children	0,04	1%	1,23	10%
Washing clothes	0,54	17%	2,64	21%
Other (animals et cetera)	0,48	15%	0,03	0%
Total	**3,24**	**100%**	**12,30**	**100%**

Not only did village B use 380% more water than village A, but it used 530% more for washing and bathing. Not surprisingly, the proportion of trachoma sufferers in village B was only half of that in village A.

THE WATER SUPPLY POSITION IN SOUTH AFRICA

South Africa is not well endowed with water resources. Not only is the average rainfall of 500mm/year significantly less than the world average of 860mm/year, but its distribution is extremely uneven - both spatially and temporally. The groundwater sources are limited and can only sustain small communities, and are often compromised by unacceptably high levels of, e.g. fluoride and nitrate. Finding a water source of sufficient *quantity* is therefore an obvious problem. Moreover, a high degree of indirect reuse is taking place (i.e. the effluent of an upstream community is later used by a downstream community) which also leads to a decline in natural water quality. Given these constraints, the following statistics do not come as a complete surprise (Muller, 1994):

Approximately 12 million South Africans (3 out of 10) lack access to a safe water supply. (This is contrasted with about 2000 million people (4 out of 10) worldwide)

There is a large discrepancy between the level of water supply in rural and urban areas. In the urban areas 20% of the population is currently unserved in comparison with 47% of the population in the rural areas.

Even for those South Africans which currently have access to water, the distance to the water is often unacceptably long. Only 74% of households have a water supply within 100m of their homes, 8% between 100m and 500m and 18% further than 500m.

As a result, there are about 30000 water and sanitation related deaths per year in South Africa. Worldwide, about 18 million deaths per year are ascribed to water-borne diseases - equal to a chilling 50000 deaths per day.

As a consequence, the improvement of water supply to all South Africans is currently a high national priority. This priority has already been incorporated into the Interim Constitution of 1994: *"...every person shall have the right to an environment which is not detrimental to his or her health and well-being..."*, which has clear implications for water supply. In the Bill of Rights of the Draft Constitution of 1996, this priority has been similarly formulated :*"...everyone has the right to an environment that is not harmful to their health or well-being..."*.

To supply water of adequate quality and quantity to all South Africans is a daunting task. It is obstructed, firstly, by a natural scarcity of water, and secondly by the logistics and costs of creating a massive infrastructure over the next five years. Although the White Paper on Water Supply and Sanitation Policy (Department of Water Affairs, 1994) has the long term goal that every South African should have accessible water and safe sanitation, it has, in the light of harsh realities, been forced to temper its guidelines for water supply to standards which might by disappointing to some, but which may be realistically attainable:

A safe water supply should be within 200m of each household.

A minimum quantity of 25 litres per person per day should be available.

A water supply point should provide a minimum flow rate of 10 litres per minute.

A maximum of one week non-supply per year, can be allowed.

There is no doubt that the attainment of these goals will be an enormous achievement, and that it will improve the quality of life for millions of South Africans. For the improvement of public health, it is important that a balance is struck between the objectives of supplying water in sufficient *quantity* and satisfactory *quality*.

SUMMARY AND CONCLUSIONS

This article has dealt with the multi-faceted link between water supply and public health. The generalconclusions drawn from the experience of developed countries over the past hundred years, are:

The provision of safe and adequate water does not guarantee a reduction in water-borne and water-washed diseases. Although it may be important, it is only one of a series of public health determinants such as food hygiene, sanitation *et cetera*.

The selection of the best water source, and an appropriate draw-off point is the first step towards securing a safe water supply.

It is necessary to subject the water to proper treatment to safeguard the health of the consumers.

After treatment, water should be protected from recontamination in the distribution system.

The integrity of a water supply can only be ensured through operating and maintaining the system with skilled, dedicated personnel.

In developing countries such as South Africa, water is, in many cases, not delivered into the home, but supplied at a communal supply point or standpipe as distance away from the home. Under these circumstances, the following additional factors need to be taken into account:

Significant bacterial contamination can take place between collection and consumption, due to open or dirty containers used for haulage and storage.

For developing communities, it is equally important to supply water in adequate quantity in addition to adequate quality.

The quantity of water consumed is directly related to the collection time. Water consumption will only increase appreciably if the water is supplied within about 3 minutes of collection time.

The deficiencies in South Africa's present water supply position, is currently being addressed through an ambitious programme in the RDP. The water supply goals for South Africa, however, need to be tempered due to natural and monetary constraints.

Although the water supply goals are modes in comparison to those of developed countries, their attainment could make a significant improvement to public health, provided other health determinants are simultaneously addressed.

Finally, the following pointers have emerged for South African planners of future water supply systems:

Larger, regional water supply schemes should be preferred to numerous smaller undertakings,

(vervolg van Bladsy 26)

transkulturele verpleging, word verpleegkundige kurrikula teenoor die kriteria gemeet en riglyne word opgestel vir dosente aangaande die beplanning, aanbieding en evaluering van transkulturele konsepte in die kurrikulum ten einde kultuur-kongruente verpleging te bevorder.

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