IMPACT OF POORLY MAINTAINED WASTEWATER AND SEWAGE TREATMENT PLANTS: LESSONS FROM SOUTH AFRICA

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ABSTRACT

Poor operation and maintenance of wastewater and sewage treatment infrastructure is a cause for concern in South Africa. Many water quality studies conducted in South Africa revealed that this problem contributes to the pollution of water resources upon which most rural communities depend for all their domestic and other purposes. Pollution as a result of poor wastewater and sewage treatment infrastructure has a direct impact on human health and the environment. This study aims to identify the root causes of the problems found in a number of case studies conducted by other investigators. Analysis of the selected studies showed that the problem of poor operation and maintenance has its underlying causes that can be addressed at various government levels. Certain problems experienced in municipalities are specific to each municipality while others are a general concern across all the municipalities. This study generated some essential baseline information of the underlying causes to the problem of poor operation and maintenance of wastewater and sewage treatment plants in South Africa.

INTRODUCTION

Since 1956, South Africa made it mandatory through the South African Water Act (Act 54 of 1956) that effluent be treated to acceptable standards and returned to the water course from where water was originally obtained(1). As the demand for water increased due to economic expansion and population growth, wastewater and sewage treatment plants increasingly operated under stress. This situation in turn exerted pressure on water and sanitation authorities to find ways to sustain the quality of water resources. Climate change and global economic concerns are also putting pressure on South Africa's ability to develop and sustain its water and sanitation infrastructure in order to meet the Millennium Development Goals (MDGs). Within this context there is increasing concern regarding the quality of South Africa's water resources (2) and the contribution of untreated effluent or poorly treated waste water discharges to the deteriorating water quality.

Effluent discharge investigations are among the methods used by many researchers and institutions as a tool to supervise the quality of water for the management of point-source effluents (3)(4). Many investigations conducted have so far indicated that wastewater and sewage effluent from treatment plants and deteriorating infrastructure is a major source of pollution, contributing to a number of pollutants found in water resources. Groundwater is also at risk of being polluted by leachate discharging from stationary effluent leaking from treatment plants. In 2008, a number of incidents of water pollution due to sewage discharges from municipal wastewater and sewage treatment plants were reported (5).

Municipal raw water or treated effluent is discharged from specific point-sources and channelled into the receiving waters such as streams, rivers, lakes, ponds and ground water. Point-source pollution problems not only increase treatment costs considerably, but also introduce a wide range of potentially infectious agents to water that may be supplied to many rural communities, thus resulting in incidences of waterborne diseases with far reaching socio-economic implications(6).

The declining state of municipal wastewater and sewage treatment infrastructure in South Africa is one of the largest contributing factors to the numerous pollution problems experienced in most parts of the country and a major contributor to health problems in poor communities, as illustrated by recent outbreaks of cholera. The Mail and Guardian (2004) reported outbreaks of cholera in Delmas, Mpumalanga Province where there were 380 cases of diarrhoea, 30 suspected cases of typhoid fever and nine confirmed cases (7). Also, there were outbreaks of typhoid fever in many parts of South Africa, including KwaZulu-Natal, Limpompo and the Transkei (8) with some latest outbreaks occurring in Delmas, Mpumalanga. The outbreak originated in the town's water supply, suspected to have been contaminated with human faeces. Another incident occurred in the Eastern Cape where 94 patients were treated with diarrhoea symptoms while 18 babies died (9). This incident was ascribed by the UKhahlamba District Municipality to microbiological water quality attributed to sewage spills from catchment based land activities (9). Spillage of untreated sewage also has adverse effects on the environment. For example, in 2008, there were media reports in KwaZulu Natal claiming that large amounts of sewage effluents were being discharged into the Durban harbour killing a large population of fish and destabilizing aquatic ecosystems(10). Groundwater pollution research conducted in the Western Cape indicated that there were increased levels of toxic minerals in groundwater samples due to seepage from the wastewater treatment plants. Many studies investigating these problems traced the pollution of water resources to design weaknesses, overloaded capacity, and faulty equipment and machinery of municipal wastewater and sewage treatment plants (11).

This paper attempts to trace the underlying causes of municipal waste water treatment failures by reviewing four studies conducted by other researchers representing a range of pollution scenarios with a view to identifying the commonalities in the problems and their proximate and distal causes. These studies are presented in the form of case studies in this paper. The objective is to consolidate the learning from the different case studies and, using a systems approach, investigate if there are common causes that contributed to the different problems. This may assist in the decision making processes on how best these problems can be dealt with, as the root causes, and thus most effective places to leverage change, are identified. It is hoped that this information will contribute towards improved functioning of municipal wastewater and sewage treatment plants.

MATERIALS AND METHODS

Supportive information in this paper is gathered through literature review. The information is presented in the form of case studies representative of the work conducted by different investigators and institutions. Sources of information were selected based on the validity, rather than on representativeness to ensure that information rich case studies are presented. Each case study is reported using a systems approach and a consolidated discussion of case studies if presented in a tabular format. Causes leading to the identified problems are given units in order to uncover the frequency of their occurrence across the case studies. From the results it should be possible to obtain an overall picture on the primary causes that lead to the visible problems presented in the case studies.

CASE STUDIES

The case studies discussed in this paper indicate that sewage discharges by some treatment plants in South Africa are a cause for concern. Most Local Municipalities located in low income communities discharge effluent that does not meet the minimum legal discharge standards. For example, in the Eastern Cape over 80% of treated effluent does not meet the minimum legal discharge standards (12). If this situation continues, it is expected that such municipalities will increasingly experience increased health and hygiene challenges. Already, in some areas of the Eastern Cape and KwaZulu Natal certain municipalities experienced health problems related to sewage spills. In the area of uKhahlamba District Municipality, Eastern Cape, sewage spills reported in 2008 led to explosion of wastewater related sicknesses and deaths on local communities. A similar situation was also reported in KwaZulu Natal where large amounts of sewage effluents were discharged into Durban harbours. However, this occurrence is not unique to poor areas, some incidences were also reported in largely developed areas of South Africa like Gauteng and the Western Cape. However, according to the case studies, low income communities are worse affected than their counter parts.

A number of factors indicated in the case studies contribute to the problem of untreated sewage and poor quality wastewater discharges. These factors include inadequate waterborne sanitation systems, malfunctioning pumps, inefficient treatment plants, poor plant designs, and poor operation and maintenance. The driving forces behind these factors will be elaborated in the four case studies discussed below.

Inadequate Waterborne Sanitation in Keiskammahoek

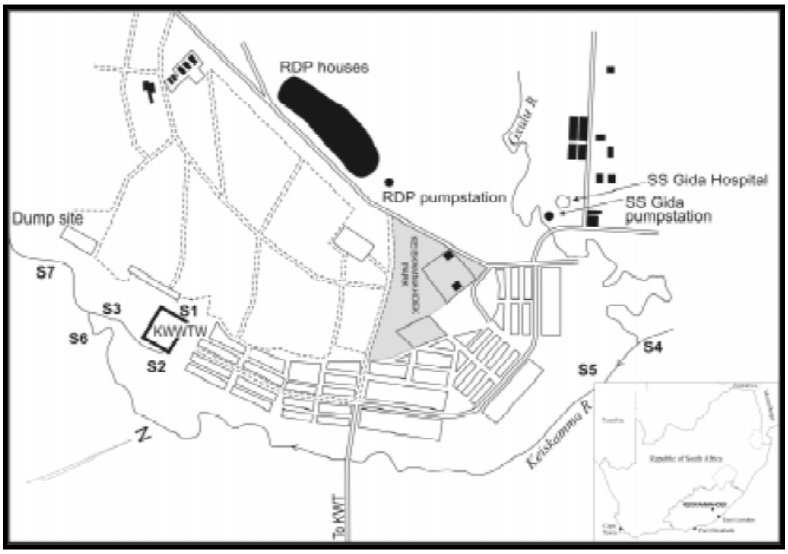

Figure 1: Map of Keiskammahoek in the Eastern Cape (Source: Morrison *et al.,* 2001).

Keiskammahoek is a small town situated between Stutterheim and Hogsback in the Eastern Cape Province, South Africa. It is part of the Amatole District Municipality which consists mostly of low income communities. The problem presented in this case study is based on a study conducted by Morrison *et al.* (2001) in the portion of the Keiskamma River located in the Amahlathi Local Municipality. In their study, Morrison *et al,* (2001) revealed that raw sewage discharges resulting from the inadequate Keiskammahoek Sewage Treatment plant, contributed to increased oxygen demand and nutrient loading of the water bodies. This problem in turn led to algal blooms and destabilized ecosystems.

The problem can be traced to a combination of three factors: an inadequate treatment works, a malfunctioning pump station, and poor planning for expansion. The problem started when the municipality built a very simple wastewater treatment plant to address wastewater and sewage treatment needs for the Keiskammahoek community. Unfortunately, from the planning phase, the design of this treatment plant did not provide sufficient capacity to treat the existing volume of wastewater and sewage influents and did not consider the possibility of population growth in the near future. As reported by Morrison *et al,* (2001), poor planning in the construction of RDP houses compounded the problem. RDP-housing units constructed in this area were connected to the same treatment plant without considering the low capacity of the plant. In the planning process there was neither enlargement of the reticulation system nor improvements on the capacity of the treatment plant. Too high inflow load into the Keiskammahoek treatment plant resulted in a poor level of wastewater and sewage purification which in turn flowed into Keiskamma River leading to the pollution of this water source (1). Other factors that contributed to the pollution of Keiskamma River included malfunctioning of the pump station in which raw sewage would bypass the pumps to be discharged straight into Gxulu River, a tributary of Keiskamma River (Figure 3). The polluted water of Keiskamma River exposed the Keiskammahoek community into serious health hazards as these communities would use this water for a variety of activities including drinking and recreation without prior treatment. The extent and the causes of the problem are presented in the form of a systems diagram shown in Figure 2.

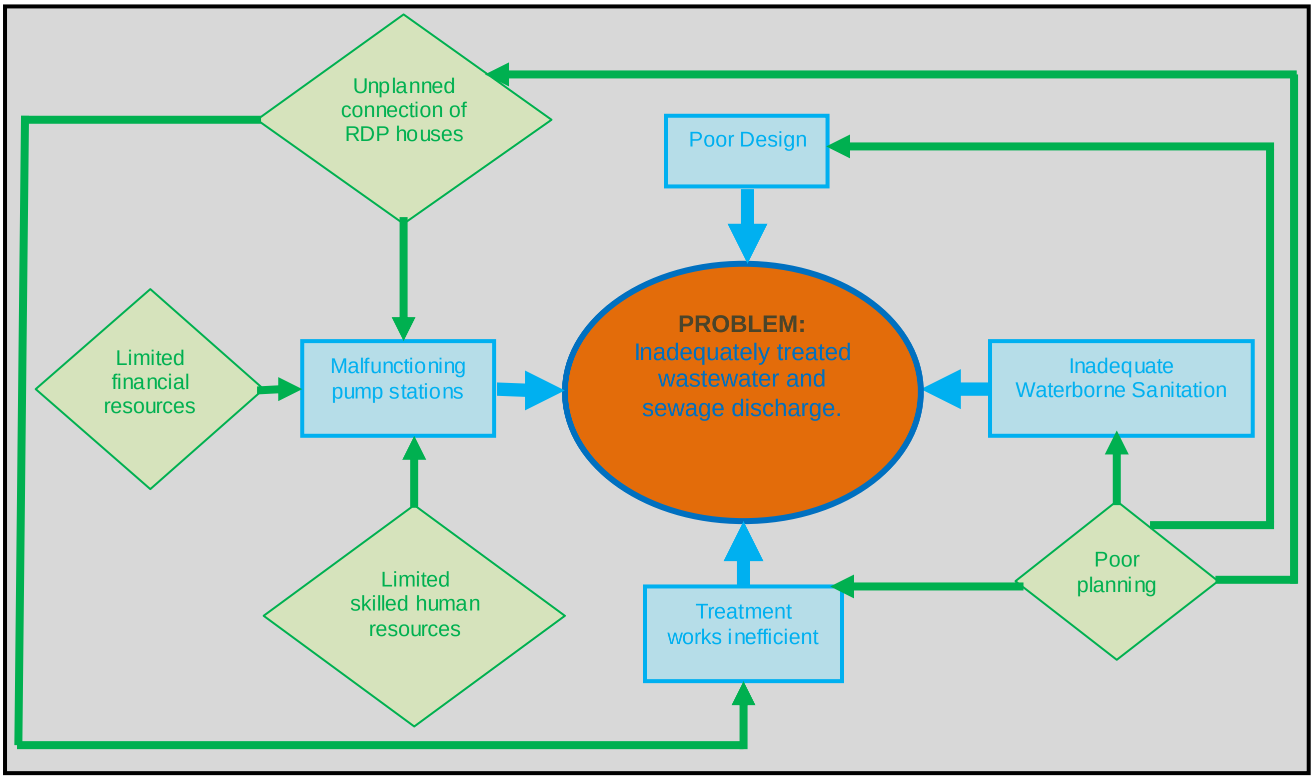

Figure 2: A schematic diagram demonstrating factors that led to the problem in Keiskammahoek Treatment Plant

Besides poor plant design, Figure 2 also illustrates some underlying factors that contributed to the problem of the Keiskammahoek treatment plant. For example, because of limited financial resources and lack of skilled personnel, the treatment works became inefficient as the pump stations would malfunction regularly. On the other hand, the costs for purifying the polluted surface waters to portable standards and the treatment plant infrastructure proved to be very expensive for this municipality. Another underlying factor was the issue of poor planning. As a result of poor planning, the construction of RDP houses in Keiskammahoek further exacerbated the inefficiency of the treatment works as well as affected the design of the treatment plant. This situation in turn led to inadequate waterborne sanitation system in the area. From Figure 2 and the study conducted by Morrison *et al,* (2001) it can be deduced that causes that led to poorly maintained wastewater and sanitation treatment plants can be traced

Buffalo City and Nkonkobe Municipalities

The efficiency of the treatment plants in the Buffalo City and Nkonkobe Municipalities (i.e. Dimbaza, East London, Alice and Fort Beaufort) was investigated by Momba *et al.* (2006). Notably, like the Keiskammahoek treatment plant, these treatment plants are situated in low income communities (rural areas). The investigation in these treatment plants was mainly focused on the removal of microbial and chemical contaminants by the treatment plants from the effluent treatment discharges. The study discovered that although the treatment plants were able to remove some pathogens from the influent, effluent discharges were only occasionally devoid of the organisms(11) a condition that posed a health threat from infectious diseases. An analysis of this case study shows a number of causes that led to the inefficiency of these treatment plants. These causes are shown in Figure 2 and have led to the inadequate removal f nutrients and chlorine overdose in the treatment plant.

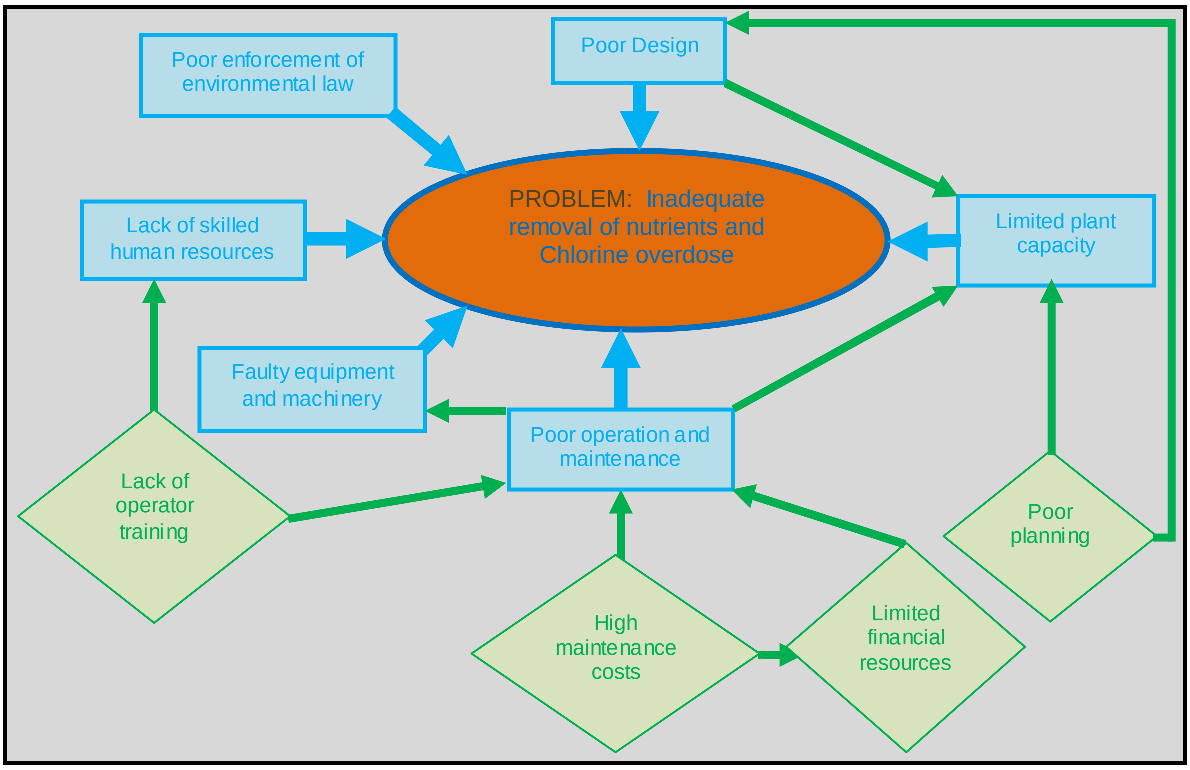

Figure 3: A schematic diagram demonstrating factors that led to the problems in Buffalo City and Nkonkobe Municipalities treatment plants

Figure 3 shows that among the causes that led to the problems in the Buffalo City and Nkonkobe municipalities, poor plant design, poor enforcement of environmental law, lack of skilled personnel and, poor operation and maintenance were identified as the underlying factors to the problems included lack of operator training, high maintenance costs, limited financial resources, faulty equipment and machinery, and poor planning. All these factors put together contribute immensely to poor operation and maintenance which in this case impacted on the quality of water resources. Furthermore, lack of skilled personnel and use of untrained plant operators became manifest after high concentrations or overdosing of chlorine residuals were noted during the month of August and September 2003 in Dimbaza and Fort Beaufort treatment plants (see Table 1). Although there were no guidelines on any standard for the concentration of free chlorine residual in the treated effluent in South Africa during the time of this study, recommended ranges of 0.3 – 0.6mg/l for the domestic water supplies as reported by Mooijimann *et al.* (2001) were used as ideal (Momba *et al.,* 2006). Fortunately, the overdosing of chlorine at certain periods of time did not have any impact of the receiving water resources as mean chlorine concentrations in the final effluent complied with the 0.3mg/l (Momba *et al.,* 2006). During the same period, mean concentrations of the final effluent for East London and Alice treatment plants were found between the recommended ranges. The overdose in chlorine residual in the final effluents could be indicative of poor understanding by the operator of how the treatment plant should be operated and why.

Table 1: Concentration of free chlorine residual in the final effluent (Momba *et al.,* 2001)

Wastewater treatment plant	**Chlorine residual (mg/l)**			
	Ranges	Means	Ranges	Means
Dimbaza	0.53 – 3.50	1.67	0.16 – 0.37	0.31
Easte London	0.19 – 0.67	0.52	0.24 – 0.54	0.37
Alice	0.14 – 0.66	0.29	0.24 – 0.39	0.33
Fort Baeufort	0.05 – 1.40	0.49	0.32 – 0.48	0.39

Changes in the treated influent from the treatment plant into the receiving body may also affect the ability of the aquatic ecosystem to support aquatic life. Some of the factors that would contribute to this condition are the levels of Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), and total nitrogen and phosphate. High levels of wastewater and sewage discharge largely affect the oxygen balance, nitrogen and phosphate concentration in the waters of the receiving bodies. Receiving water bodies affected in this way are disqualified as aquatic ecosystems as they become unable to sustain aquatic life (11).

Since South Africa did not have guidelines for the acceptable levels of BOD in effluent Momba *et al*. (2001) used EU guidelines to determine whether BOD levels fall within the range 3.0mg/l – 6.0mg/l as recommended by EU guidelines (13). The study by Momba *et al.* discovered that BOD levels in all the effluents from the different treatment plants and receiving water bodies were much higher than those recommended by EU guidelines. On the other hand, the DO levels of the effluents and the receiving bodies which are recommended to range between 8 and 10 mg/l by EU were less than 5 mg/l (except for East London and Fort Beaufort treatment plants), a level that would adversely affect aquatic ecosystem. The levels of nitrogen were found to be normal while phosphates levels (3.1 – 6.8mg/l) exceeded the recommended level 0.035 mg/l. Poor monitoring and evaluation of Alice, Dimbaza, East London and the Fort Beaufort treatment plants led to inadequate removal of nutrients by these treatment plants. Their phosphate discharge impact was observed in the Tyume River, Tembisa Dam, Nahoon and Eastern Beach, and Kat River which acted as their receiving water bodies.

Unfortunately, municipalities that service low income communities do not strictly enforce environmental laws which tend to subject their communities to health risks and lead to environmental degradation. Operation and maintenance situation in Buffalo City and Nkonkobe Muncipalities was obviously not hopeless during the time of this study. However, training of operators would have contributed positively to the betterment of the quality of effluents discharged from the treatment plants and therefore improve their functionality.

Cape Flats and Zandvliet(WWTP)

Although a lot has been reported on the pollution of surface water by Wastewater Treatment Plants (WWTP), not much has been reported on the pollution of groundwater by the same factor. A study by Parsons (2002) investigated the impact of wastewater treatment plants on groundwater. Parsons conducted geohydrological studies on groundwater in the vicinity of three WWTP, namely, the Cape Flats WWTP, Zandvliet WWTP and Bellville South WWTP (14) (Figure 4). In this case study, discoveries on only Zandvliet and Cape Flats wastewater treatment plants are looked at.

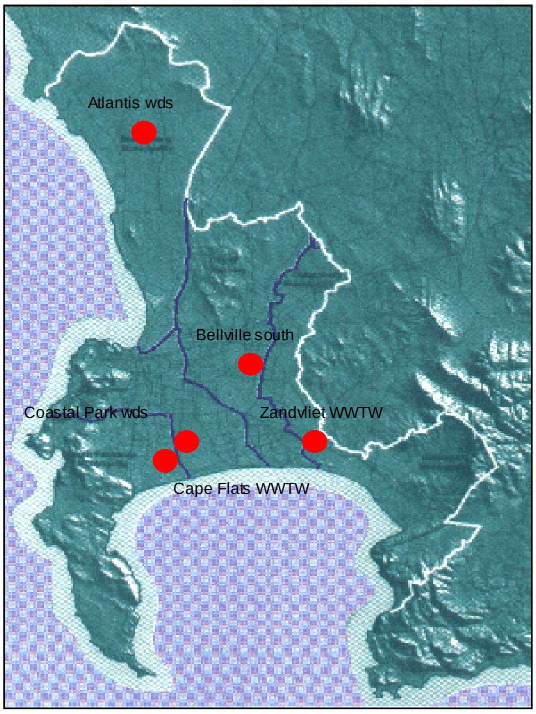

Figure 4: Location of WWTWs and waste disposal sites (14)**.**

A report by Parsons (1998) cited by Parsons (2002) indicated that a study on groundwater at Zandvliet WWTP was initiated following a spill from temporary sewage sludge lagoons. On the other hand, a study on discharges from Cape Flats WWTP was conducted by Southern Water (2002) also cited by Parsons (2002) to facilitate the remediation of groundwater pollution of Zeekoevlei and Rondevlei. Findings of this study showed that groundwater in this area have high levels of nutrients (34%), a clear indication that these treatment plants have a significant impact on groundwater contamination. Spills from Zandevlei WWTP resulted in high concentrations of potassium and nitrogen on groundwater. These minerals were found in excess of 80 mg/l and 160 mg/l consecutively exceeding ambient levels which are generally less than 2 mg/L. Investigations by

Southern Waters (2002) discovered that about 35% of the annual phosphorus load discharged into Zeekoevlei was from the Cape Flats WWTP. The rest of the phosphorus came from the Big Lotus River catchment (28%) and sediments trapped in the vlei (25%)(14). The concentration of phosphate discharged was at 7.5 mg/L which was much higher than ambient concentration less than 0.1 mg/L (Parsons, 2002) whereas the concentration of nutrients discharged into the sea was about 205 orders of magnitude more than anywhere else along the northern shore of False Bay. A closer look at this study shows that there are a number of factors from which these spills have resulted. Figure 5 is a systems' diagram demonstrating factors that led to effluent discharges from these wastewater treatment plants.

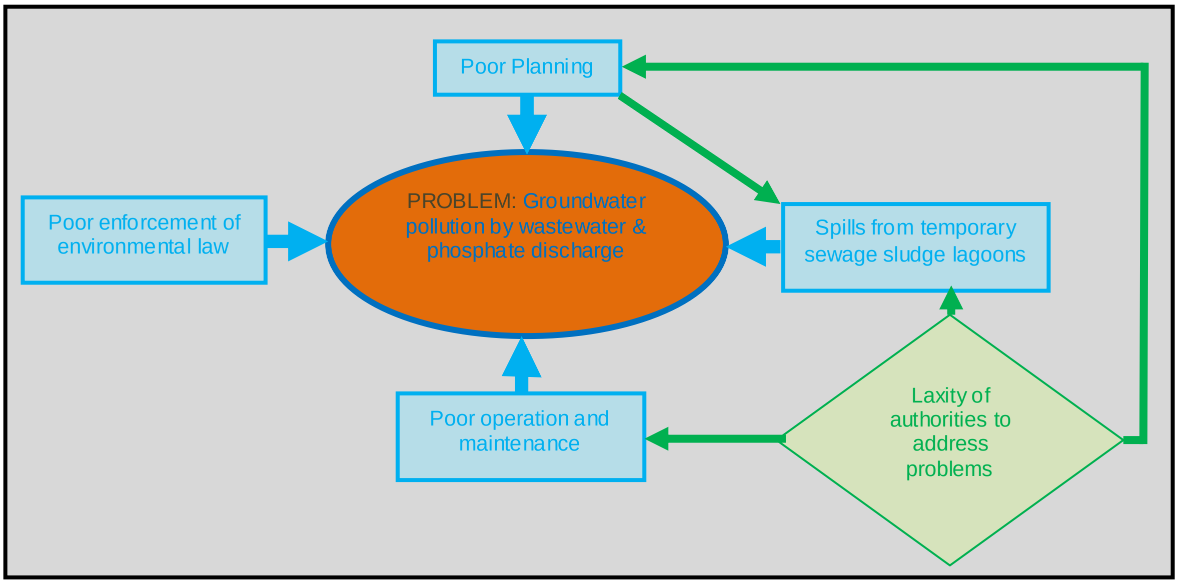

Figure 5: A schematic diagram demonstrating factors that led to spills in Zandvliet and Cape Flats Treatment Plants.

The problem of spills from Zandvliet and Cape Flats WWTP was traced from factors such as laxity of authorities to respond promptly to problems arising from these plants (see Figure 5). Depending on the promptness of authorities to address problems arising from the WWTP spills, the impact on groundwater quality may be little if not insignificant. For example, in 1998 sludge spills had little impact on groundwater quality, a situation ascribed to prompt remedial action by the responsible authorities (15). In situations where authorities did not respond promptly, impact on groundwater was noticeable (Parsons, 2002). This is an indication that action by authorities is very central to ensuring proper functioning of wastewater treatment plants (WWTP). The laxity of authorities contributes, among other things, to poor operation and maintenance, poor planning and may also mean poor enforcement of environmental laws (see Figure 5).

Problems like high levels of phosphorus (7.5 mg/l) detected on the receiving waters in Zeekoevlei could be reduced through proper planning and proper catchment management. Poor sludge management practices, particularly the disused sludge drying beds and temporary sludge lagoons were one of the causes of groundwater pollution impacts at Zandevlei WWTP (Parsons, 2002).

Although impact on groundwater have been traditionally associated with waste disposal sites this case study shows that impact by wastewater treatment plants on groundwater is equally comparable to that of waste disposal sites. There is need for guidelines to monitor effluent spills from wastewater treatment plants to reduce their impact on groundwater.

Pollution of Water Resource by Industrial Effluent in KwaZulu Natal

Investigations conducted by various researchers in water resources of KwaZulu Natal indicated a rise in faecal coliform counts. Bezuidenhout *et al.* (2002) conducted a study in Mhlathuze River which showed that in the year 1998 to 1999 the mean total coliform counts were generally double the faecal mean coliform counts. As a result of this, communities in the Mhlathuze River catchment were prone to water-borne diseases (Pegram *et al.,* 1998 cited by Bezuidenhout *et al.,* 2002). The schematic diagram below indicates various factors that led to the discharge of untreated or incompletely treated wastewater and sewage discharges into the water catchments.

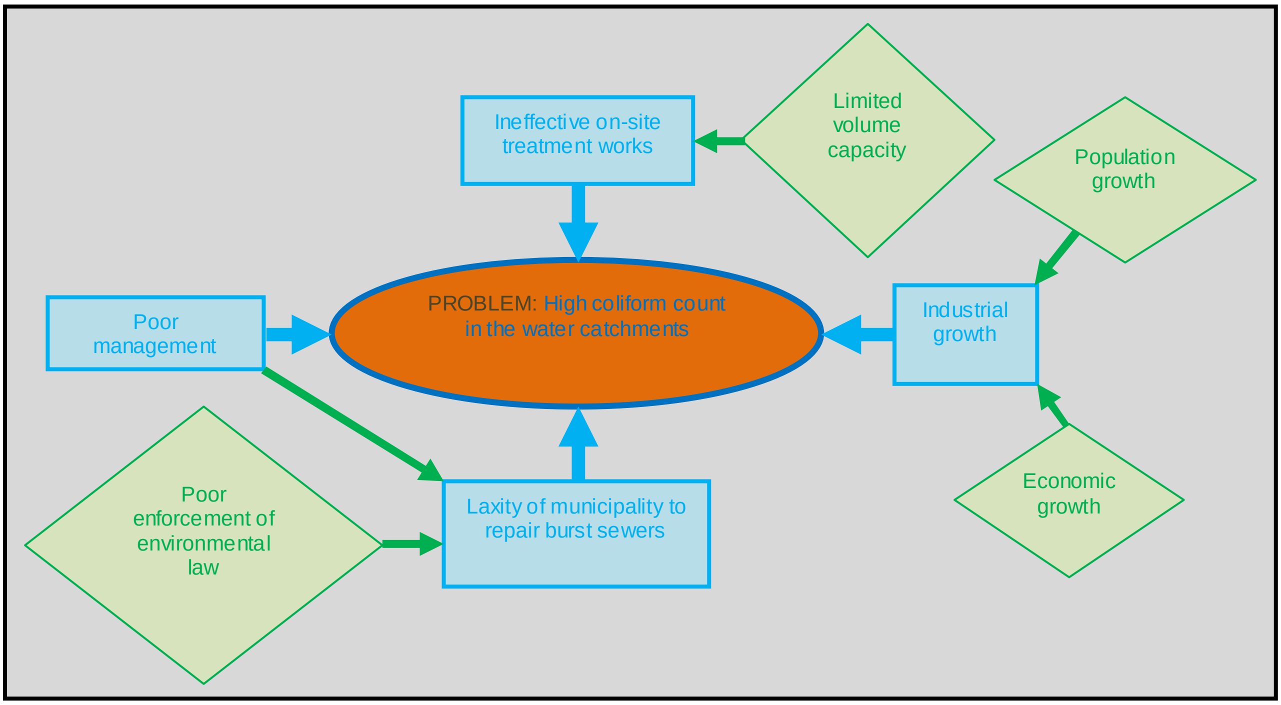

Figure 6: A schematic diagram demonstrating factors that led to the pollution of water resources in KwaZulu Natal by effluents from treatment plants.

Factors contributing to high coliform counts in the water catchments of KwaZulu Natal include industrial growth, poor management, laxity of authorities and ineffective industrial on-site treatment plants. Underlying to these factors is poor enforcement of environmental laws, economic growth, population growth and limited capacity (see

Figure **6**). The state of increasing small, medium, and corporate industry in KwaZulu Natal led to large volumes of wastewater being discharged into the water resources. For example, chemical industries in the Vaal Barrage Catchment use 9.1 Ml of water and produce 4412 m3 effluent/day containing 9264 kg COD/day pollution loads and total dissolved solid loads of 15990 kg/day (Bux *et al.,* 1998). These amounts far exceed the standards set by DWAF for the discharge of effluents into natural water courses where COD levels should not be more than 75 mg/l (16). Industries discharging effluents with COD levels exceeding 75mg/l are subjected to fines that may affect the financial output of the industry. To avoid these fines certain industries resolved to treat their effluent on-site before discharging it into water courses. However, a study conducted by Bux *et al.* (1998) revealed that on-site treatment plants were not effective enough to treat the industrial effluents. Some failures included their inability to sustain the pH and to clear the colour of the final effluent because of high COD levels in the effluent.

There have also been media reports about large amounts of sewage flowing into the Durban harbour as a result of punctured sewage pipes (see Figure 7) (17). According to Daily news (2008), this was due to laxity of the municipality to repair burst sewer lines and poor management at some wastewater sewer plants(17).

Figure 7: Heavily polluted water in Durban harbour (www.deathofdurban.blogspot.com).

This problem began to show in 2006 when the levels of E.coli started to indicate a significant increase in some rivers such as Mlazi River. According to this report, although this was reported to the authorities, little was done to correct the problem. Extremely high levels of E.coli (440 000 counts/100ml vs. 130/100ml acceptable levels) were reported later in the Isiphingo River (18). These spills heavily affected marine life in the area through massive fish kills which could have health and economic implications in the province of KwaZulu Natal if this problem persists. Human health and wild life may also be seriously affected as some people and wild life may start to feed on both dead and living but contaminated fish.

With increasing demands on water resources and contamination from both, industry and municipal treatment plants due to increased human activities, the potential outbreak of waterborne diseases according to this case study continue to grow. Opportunistic pathogens may have serious implications for the low income consumers who consume water directly from the river without prior treatment.

DISCUSSION OF CASE STUDIES

Table 2 is a consolidation of the factors that led to the problems as indicated in the case studies. The causes that led to the bigger problems are tallied as they appear in each case study. This is done in order to determine their frequency as they appear from one case study to another. At the bottom of the table is the sum of the tally marks.

Table 2: An overview of causes that led to the problems in the case studies

Case studies						Frequency of the causes of the problems across the case studies (Tally marks)
Name of Case study		Inadequate water-borne sanitation in Keiskammahoek	Buffalo City and Nkonkobe Municipalities	Cape Flats ad Zandvliet (WWTP)	Pollution of water resource by industrial effluents in KwaZulu Natal	
Problem reflected in the case study		Untreated sewage and wastewater discharge	- Inadequate removal of nutrients - Chlorine overdose	Groundwater pollution by wastewater and phosphate discharge	High coliform count in the water catchments	
Causes of the problem as reflected in each case study	Poor design	I	I			II
	Poor planning	I	I	I		III
	Inefficient treatment works	I	I		I	III
	Inadequate waterborne sanitation	I				I
	Limited skilled personnel	I	I		I	III
	Limited financial resources	I	I			II
	Poor law enforcement		I	I	I	III
	Lack of Training		I			I
	Population growth			I		I
	Economic growth			I		I
	Industrial Growth			I		I

As observed in Table 2 some of the causes that led to the problems indicated in the case studies are more common across the case studies than others. The causes that appear more common in these case studies are poor planning, inefficient treatment plants, limited skilled personnel and poor law enforcement. Each of these causes appears in at list three case studies hence the sum of lll. Poor plant design is the next culprit in the ladder appearing in at list two case studies. The rest of the causes are unique in each case study making their impact on poor operation and maintenance more situational.

As shown in the schematic diagrams of each case study some causes are primary causes while others are secondary causes. Primary causes are the underlying causes to secondary causes. The secondary causes are those that appear to be directly linked to the visible problem. For example, poor planning, limited financial resources, limited skilled personnel, lack of training are primary causes which are drivers of secondary causes such as inefficient treatment works, poor design, poor enforcement of environmental law, poor management. Depending upon each case study influence of causes may vary i.e. primary causes in one case study may be secondary in another and vice versa.

MEASURES BY THE SOUTH AFRICAN GOVERNMENT TO MANAGE THE CURRENT SITUATION OF THE TREAMENT PLANTS

The aging wastewater and sewage treatment infrastructure against rapidly growing needs has led to renewed emphasis by the government on scaling up infrastructure investments as part of broader policy efforts to lay foundation for accelerated and pro-poor economic growth and more rapid economic and social integration of the society (19). Through failing infrastructure and its consequences the South African government has learnt strong lessons from underestimating the importance of investing on infrastructure operation and maintenance. Effective water and sanitation service delivery scale-up requires an assessment of performance of wastewater and sewage treatment infrastructure. This is precisely the mandate of South African government since 2004 to sustain economic growth through the provision proper and holistic basic services. According to the Department of Water Affairs and Forestry (DWAF: 2002) provision of these basic services must be based on the principles of accountability, transparency and improvement of intervention performance.

Through the strength of DWAF and Department of Provincial and Local Government (dplg) the government monitors and evaluates policy outcomes and regulates the municipal infrastructure investments. DWAF, as a water sector assesses the outputs of basic water services provision which includes treatment of wastewater and sewage by dplg (MIG) through on-site spot checks of projects (20). The approach to on-site spot checks of projects assumes that bulk-water and -sanitation projects are carried out according to a strategy that underpins a particular policy as stipulated by DWAF in the water and sanitation white paper. This will in-turn accelerate a quick corrective measure that will inform future implementation processes as well as allow refining of policies, strategies and frameworks (CSIR and DWAF 2008).

CONCLUSION

Investigations conducted in the water resources of South Africa have shown that poor operation and maintenance of wastewater and sewage treatment plants have a great impact on both the environment and human health. Ignorance to properly maintain wastewater and sewage treatment infrastructure has led to effluents with various types of pollutants being deposited into water resources. Poorly maintained wastewater and sewage treatment plants are at list comparable to factors resulting from lack of response from both local and national government. It is therefore illogical to build more wastewater and sewage infrastructure without addressing the underlying factors that lead to the failure of this infrastructure. Although South Africa has put in place good measures to address this problem there is need to transform these measure from paperwork into action.

Recommendations

Analysis of the case studies shows that most of the problems pertaining to poor operation and maintenance of wastewater and sewage treatment plants are well known. However, limited knowledge on the impact of the causes leading to the problems may be the reason most of these problems have not been effectively addressed. It is also evident that problems experienced at the treatment works can be categorised as those that can be addressed by the national government and those that require the attention of the municipalities. Problems that appear to be common in all case studies may require the intervention of the national government for them to be addressed while the problems that are specific to each municipality may require the national government to necessitate accountability from the municipality in question. The program of monitoring and evaluation should not be seen as solely the responsibility of the national government, as is currently the case, but should be taken to the level of district municipalities. The district municipalities may then report to the national government. However, the national government must conduct its own evaluation and maintenance after a specified period to evaluate the reports by the district municipalities.

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