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REVIEW ARTICLE

HISTORICAL EVENTS AND LAND USE CHANGES SHAPING THE ISIPINGO RIVER CATCHMENT, KWAZULU-NATAL, SOUTH AFRICA

Pillay, R. K., Pillay, S. and *Ballabh, H.

School of Agricultural, Earth & Environmental Sciences, College of Science and Agriculture
University of KwaZulu-Natal, Westville Campus, Durban, South Africa

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ABSTRACT

The Isipingo River and its catchment is regarded as one of the most severely impacted in KwaZulu-Natal. A series of highly publicized pollution episodes in the local media and general public outcry have cemented the impression that the degradation of the system is largely anthropogenic. This study identifies the significant land use changes following an extensive review of printed media, documentaries, photographs, prior research and interviews. The changes identified include development of a major airport, diversion of the Umlazi River, construction of river diversion works system and canalization of the lower Isipingo River. The developments have contributed to a drastic reduction in mean annual runoff from 102 to 3 million m^3/year, exacerbating estuary mouth closure, and necessitating the construction of twin pipes at the mouth to maintain tidal exchange. Intensive residential and industrial development on the river floodplain has led to the removal of indigenous and riparian vegetation. The historically poor water quality in the Isipingo River and Estuary has been related to inadequate sanitation facilities and illegal discharges of industrial effluent. The deterioration of Isipingo River system demonstrates the consequences of improper planning and over-utilization of the catchment together with poor application of regulations pertaining to the environment. This paper documents the historical land use changes and events that have shaped the Isipingo catchment and ultimately influenced the quality and quantity of water over a 172 year period from 1840 to present day.

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INTRODUCTION

The modern era has set in motion the ever increasing demand for countries to further advance the economy and to pursue avenues to enhance social lifestyle. In the past concepts such as sustainable development and environmental protection were not essential parts of the decision making process. This has lead to somewhat drastic changes in land use patterns without due consideration given to the environmental consequences of these actions. The Isipingo catchment has historically been the focus of land use changes which have dramatically shaped and influenced a number of environmental factors, in particular water quality and quantity. Major changes in land use such as industrial and urban development, with concomitant alteration to the hydrology of the catchment and encroachment onto the floodplain appear to have caused the deterioration of the Isipingo River and its estuary.

Corresponding author: Ballabh, H.,
School of Agricultural, Earth & Environmental Sciences, College of Science and Agriculture, University of KwaZulu-Natal, Westville Campus, Durban, South Africa.

This has ultimately resulted in the landscape changing from one where the Isipingo River previously flowed past beautiful mangrove habitats to the current situation we observe today, where the reduced flow of the river passes through areas of industrial development and high density housing developments.

REGIONAL SETTING

The Isipingo catchment is one of the smaller catchments located in the province of KwaZulu-Natal, with an extent of approximately 50 km^2 (Fig.1). The length of the Isipingo River is approximately 27 kilometers (km), originating near the Iwabi area (Kalicharran and Diab, 1993, Brand, 1967). The importance of the catchment lies in the fact that it has become one of the most highly developed regions in KwaZulu-Natal. The IsipingoLagoon and Estuary is located between 30°00'S and 30°57'E and is approximately 21 km south south-west of the Durban CBD (Fig.1). The main activities associated with the estuary and Lagoon is recreational, fishing and cultural practices and, at some parts of the river, poor communities living along the river have been observed using it for the

washing of clothing. The upper catchment is characterized by sparse dwellings while dense housing development dominates the central catchment. The Isipingo Waste Water Treatment Works (WWTWs) is located in the lower catchment. This facility was built in the late 1960's and discharges an average of 10.98 ML/day of treated effluent into the Isipingo River (DWAF, 2009). Other impacts on the river system derive from the rehabilitated high hazardous Umlazi IV landfill, the Isipingo Diversion Works System as well as the old Durban Airport, a number of refineries and other industrial facilities (i.e. Prospecton and Isipingo Industrial Nodes), informal agriculture and a residential area (Fig.2).

The river is canalized just after the engineered Diversion Works System (DWS) (Fig.3) through the section that passes the Prospecton Industrial Area (PIA) before reverting to natural status after the bridge located on Avenue East Road (Fig.3). The Bamboo drain (Fig.3) which joins the Isipingo River just downstream of Avenue East Road, is a conduit for drainage and run-off stemming from parts of the Central Business District (CBD) of Isipingo and, the residential areas of Isipingo Rail and Rana Road. The river then flows into the estuarine area which is dominated by a fairly large stand of mangroves. The latter stretch of the river is referred to as the northern arm.

Fig. 1. Locality map depicting the IsipingoEstuary and Lagoon in 2002

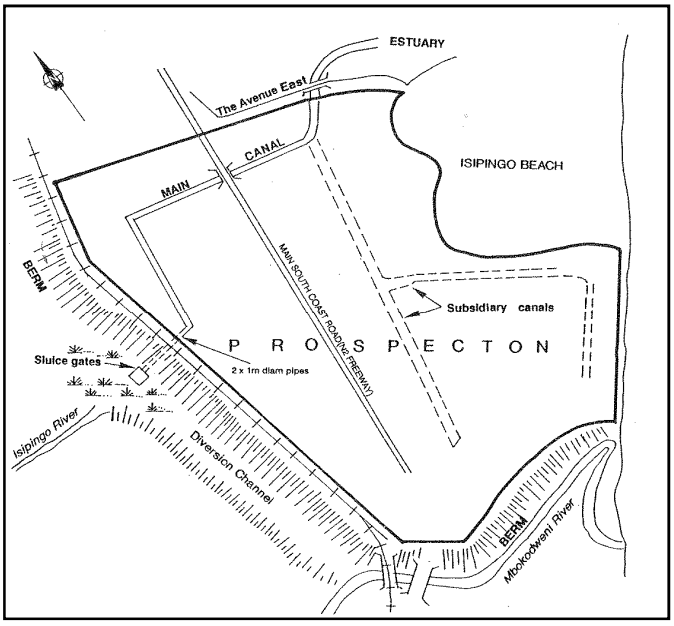

Fig. 2. Diversion Works System (DWS) Canal System (PCS) (Begg, 1978)

Approximately 200 m upstream of the mouth, the estuary bifurcates in two, the southern arm being the Lagoonal area which terminates in a small lake. Depths of 7.5 m in the Lagoon were reported in 1910 (Ward, 1971 as cited in Begg 1978). Elsewhere the Lagoon is less than 3 m deep and is particularly shallow (0.5 m.) near the mouth (Begg, 1978). The western section of the Lagoon was measured in 1984 to a depth of 5.2m. While the stretch of river flowing past the mangroves (also referred to as the Northern arm) was roughly 3.7m deep over a long section.

These included a survey of newspaper articles, prior research, documentaries and interviews. Newspaper articles published in the Natal Mercury and the local newspaper were accessed through the eThekwini Municipality.

Media reports on the estuary generally focused on pollution events or new developments. A serious of focused interviews was conducted with individuals identified as having knowledge of land use changes or having researched the system.

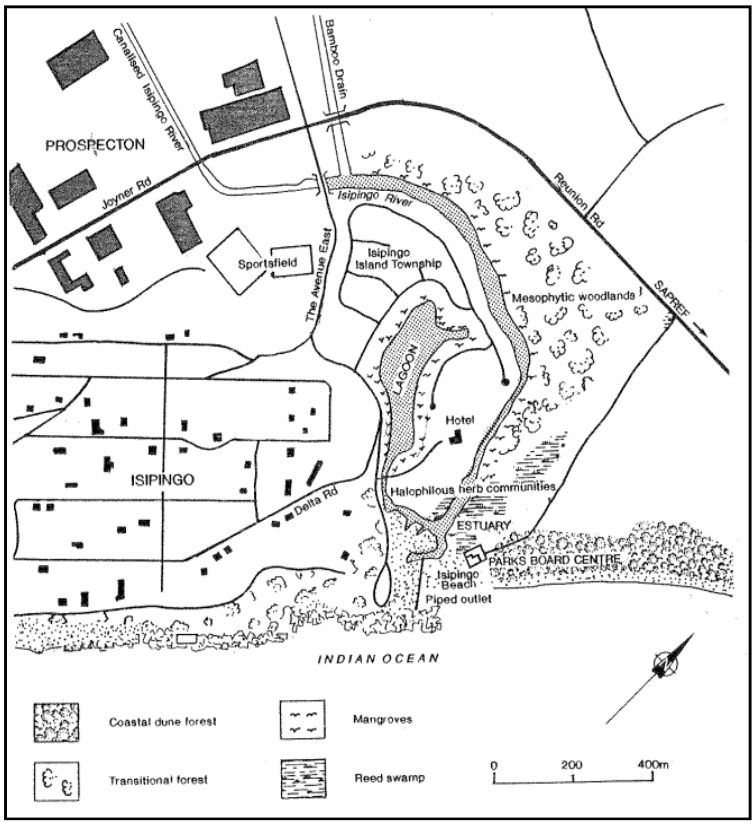

Fig. 3. Canalized portion of the Isipingo and Prospecto River and the Bamboo Drain (Begg, 1978)

More recently, a survey conducted in 2007/2008 by Marine and Estuarine Research (MER) group recorded a maximum depth of 4.4m in the Lagoon and 1.33m in the Northern arm (Forbes and Demetriades, 2008). The geology of the Isipingo catchment consists of outcrops of Table Mountain Sandstone and Dwyka rocks. Tertiary and recent sediments occur near the coast (Brand, 1967). Alluvium, modern dunes and weathered red sands surround the Lagoon (Ward, 1980). Bedrock is said to lie at a depth in excess of 22 m (Orme, 1974).

MATERIALS AND METHODS

Land use changes were determined by examining an array of aerial photographs dating back to 1930 that was made available by the eThekwini Municipality. These photographs were taken over intervals of approximately 5 to 10 years and show the lay of the land. Notable changes in land use were examined and recorded. An extensive literature review of documentation and other studies on land use changes within the catchment were examined.

RESULTS AND DISCUSSION

Vegetation

Removal of indigenous vegetation began during the early European settlement (1840-1952) (Kalicharran and Diab, 1993). This activity was undertaken to make more land available for the cultivation of sugarcane, market gardening and township development. Despite this, the Isipingo River continued to function as a healthy system (Ward, 1980). This was reaffirmed by Harris (1987, p. 3) who described the Isipingo River during the 1930's as a *'fine, clear, tree-lined river, flowing between the cane fields of the Prospecton Sugar Estates.*' In 1916, a golf course was developed on the north bank of the Umlazi River, upstream of the estuary, which resulted in the destruction of dune vegetation and forest (Fig.4) (Kalicharran, 1990). The Umlazi River joined the Isipingo Estuary at its mouth. This was diverted around 1952. Subsequently, the development of a military camp during the Second World War at Reunion Rocks resulted in further destruction to dune vegetation (Ward, 1980).

Fig. 4. Land use changes to Isipingo Beach area between 1937 and 1968 (Ward, 1980 as cited in Kalicharran, 1990)

Fig. 5. Isipingo Estuary and Lagoon showing mangroves and canals (2008) (eThekwini Municipality, 2010)

Fig. 6. Isipingo Estuary and Umlazi River in 1942 (eThekwini Municipality, 2010)

The golf course was eventually leveled off and used as an aerodrome and army camp site during this period. The original vegetation in the vicinity of the estuary consisted of mangroves, low lying woodlands, marsh and scrub in the vicinity of the estuary (Forbes and Demetriades, 2008). During 1946, the pre-construction phase of the former Durban Airport (known as Louis Botha Airport) commenced, which resulted in the removal of most of this original vegetation (Ward, 1980). Between 1966 and 1970, vast amounts of natural vegetation was removed to permit the development of the PIA (Fig.4 depicts the infill area). In 1965 virtually all the mangrove swamps on the southern bank and the central island area was reclaimed for township development (Forbes and Demetriades, 2008). In 1967, mangroves were only present along the north bank of the Isipingo (Fig.5) (Forbes and Demetriades, 2008). The year 1983 saw the removal of additional mangroves and a salt marsh located at the eastern end of the Lagoon area. There was further removal of mangroves and wetland vegetation to the west of the Lagoon but by 1989, the mangroves had colonized the south bank of the Isipingo River.

Today, the northern bank of the estuary is observed to be well vegetated with mangroves while there is no riparian vegetation encompassing the Lagoon (Fig.5). Forbes and Demetriades (2008) iterated that the eastern tip of the island and the area around the Island View Hotel are also well vegetated with mangroves while the southern bank in the region of the mouth has been cleared of vegetation for a road and car park (Fig. 5). The southern bank of the main channel is fringed with a narrow strip of mangroves. The current type of mangroves comprise primarily of *Avicennia marina, Bruguierragymnorrhiza* and *Rhizophoramucronata* (species of red mangrove found on the northern banks of the Isipingo Estuary) and inhabits an area of approximately 12.7 ha (Rajharen and Adams, 2006).

Modifications to the Catchment and Estuarine Environment

Prior to 1952, the Umlazi River joined the Isipingo River just upstream of the estuary mouth. The combined contribution to mean annual flow from these two rivers was approximately 102 million m^3/year (Swart, 1987). According to Forbes and Demetriades (2008), the Isipingo River was recorded as being as wide as 40-50 meters (m) during the 1930's and only narrowed at the bridge on Avenue East. After the Second World War in 1945, an earth berm or dyke was erected across the original course of the Umlazi River to prevent water of the north-eastern section of the Isipingo Flats from flowing towards this river (Kalicharran, 1990). This water was diverted in 1952 into a concrete lined canal draining into the sea at Reunion Rocks (Ward, 1980). This diversion reduced the discharge of the Umlazi River, which at the time still flowed towards the Isipingo Estuary, to 6 million m^3/year (Swart, 1987) and can be deemed to be the start of the restriction of flow to the Isipingo Estuary. Following the diversion of the Umlazi River in the late 1950's, the reduced fluvial flows caused protracted mouth closure of the estuary and necessitated the construction of twin concrete pipes to facilitate and maintain the tidal exchange between the estuary and the sea (Figure 2).

The severe reduction in flow to the Isipingo Estuary diminished the scouring effect at the mouth leading to wave induced sand accumulation and mouth closure. The mouth closed semi-permanently in 1952, and mechanical breaching was initiated (Forbes and Demetriades, 2008). An attempt to increase tidal interchange was undertaken in 1955 by installing a one metre diameter steel pipe through the sand bars (Ward, 1980). The failure of this attempt prompted the construction in 1961 of two concrete pipes of one meter diameter each below the sandbar (Ward, 1980) which today still provides some tidal exchange (Fig.6).

The pressures arising from the need to develop the Prospecton Industrial area (late 1960s) resulted in the flow of modification of the upper Isipingo River with the construction of the DWS in 1969/1970 (Figure 4). This system together with sluice gates was installed at the head of the Prospecton Canal System (PCS) (Swart, 1987) to regulate the flow received from the upper catchment and to permit a controlled flow to the PCS. The Isipingo River was canalized for more than 1 km above the Avenue East Bridge during this period to assist with stormwater drainage (Forbes and Demetriades, 2008) and this canal system is still in existence today. The system was designed to divert high flow levels to the Mbokodweni River during times of floods while permitting low flow levels through to the PCS and eventually the IsipingoLagoon and Estuary (Philip, 2010). The flow of the Isipingo River was thus reduced to 3 million m^3/year, only three percent (3 %) of its original flow (Swart, 1987). Due to poor maintenance and mechanical problems of the sluice gates, the flow has often been reduced further (Swart, 1987).

In November 2009, the Coastal, Stormwater and Catchment Management Section of the eThekwini Municipality undertook remedial measures. Accumulated sediment and water hyacinth was removed from the pond ahead of the DWS. The pond was created to channel and slow down the water prior to flowing through the DWS. Further excavations of the pond were undertaken and a concrete trash tract with palisade beams was installed instead of steel to dissuade theft. Maintenance is expected to be conducted every 3 months as well as immediately after heavy rainfall events to maintain the water height, remove water hyacinth and sediment in the pond. According to Sooklall (2010), the maximum flow that can be permitted through the inlet of the sluice gates calculated by engineers of the eThekwini Municipality is 5.4 m^3/s. Repairs to the DWS have been undertaken but due to the irregularities in the maintenance of the system, there are periods during which the Isipingo River, just above the DWS, is still being diverted to the Mbokodweni River.

Township and Industrial Development and Sanitation

In 1905, an unnamed township was developed at Isipingo Beach (Kalicharran, 1990), on the southern bank of the estuary (Forbes and Demetriades, 2008). Infilling of wetland areas along the Isipingo River near the DWS took place in the late 1980's (Kalicharran, 1990) and, infilling of the low-lying areas to the north of the Isipingo Estuary for the development of the South African Petroleum Refinery (SAPREF) commenced in 1961 (Kalicharran, 1990).

The Isipingo Flats from Avenue East (main access road to Isipingo Beach) was infilled in 1966, together with the canalization of the river and its tributaries to allow for industrial development (Kalicharran, 1990). The Prospecton area was infilled to three meters (3m) above mean sea level (Ward, 1980) and, in 1969 this level was increased using dredged material from the IsipingoLagoon, Estuary and the river (Fig. 7) (Ward, 1980).

These developments have led to further removal of riparian vegetation in the middle to upper catchment which has increased the degradation of the riverine system. Since 1994, there has been extension of the Prospecton and Isipingo industrial areas and the growth of more commercial industries all of which contribute to considerable increases of environmental stress upon the Isipingo River and Estuarine system.

Fig.7. The Diversion Works System (2010) showing the large concrete structure which houses the sluice gates that allows pooled water to flow into the PCS

Town Board status was granted to Isipingo Beach and Isipingo Rail in 1972 and the area became known as the Borough of Isipingo (Wiley *et al.*, 1996). Abolishment of the influx control laws (those preventing people other than of European descent from inhabiting the area) in the mid 1980s allowed informal settlements to develop and expand on the outskirts of Isipingo (Wiley *et al.*, 1996). These developments lacked the provision of basic services including proper sanitation facilities. Residences near the Isipingo Estuary and Lagoon used septic tank systems converting to waterborne sewage in the late 1960's (Gravelet-Blondin, 2010). Since 1994, the Boroughs of Isipingo and Amanzimtoti (a town adjacent to Isipingo in a southerly direction) were dissolved and now fell under the jurisdiction of the eThekwini Municipality.

The post-apartheid era resulted, through the Reconstruction and Development Programme (RDP), in the formalization of existing townships. There was a need for development of low to medium cost housing and access to proper sanitation facilities in the middle to upper areas of the Isipingo catchment and extensive upgrades to the sewer lines in the Umlazi area (located in the upper reaches of the catchment and beyond, with the main trunk sewer line being upgraded in 2006/2007 (Mhlonga, 2010).

Sand Mining

Sand mining commenced in 1961 immediately north of the Isipingo Estuary mouth (Kalicharran, 1990). This was then followed by the mining of sand on the southern side of the estuary mouth. According to Ward (2010), more than 10 million cubic meters of sand could have been removed from the system. There are no longer any sand mining activities taking place at the Isipingo Estuary or along the length of the Isipingo River.

Water Pollution

The water quality along the Isipingo River and in particular the Isipingo Lagoon and the estuary has a history of being of poor quality. Griffiths (1987) attributed the main reason for the poor water quality to faecal contamination and nutrient enrichment, apart from insufficient flow to the estuary. In 1953, Harris found the IsipingoLagoon to be polluted by effluent from the septic tank system. Sampling undertaken in 1964 and the 1970's demonstrated that both the river and Lagoon were organically and faecally polluted (Brand *et al*., 1964; Begg, 1978). Brand *et al*. (1964) also concluded that the water in the Isipingo River approximately 2.5 km above the Lagoon was chemically of poor quality.

As citied in Begg (1978), (Turner *et al*., 1974; Grindley, 1970), the Lagoon was examined for heavy metal contamination and this drew attention to pollution of the IsipingoLagoon by detergents. In 1981/1982, foaming of the water in the Lagoon was noticed and attributed to detergent manufacturers in the PIA. Griffiths (1987) noted that that the flow to the Isipingo waste water treatment works had dropped from 67% in January 1985 to 26% in March 1986 implying that the volume of sewage meant to be received by the works for treatment was not reaching the works. Instead, raw sewage ranging from possibly 3.67 to 6.7 ML/day was entering the Isipingo River and Estuary. A similar situation occurred in the latter half of 1991 when political and social unrest in the Umlazi area prevented work crew from repairing and clearing blockages to the sewer lines **(**Rankin, 1992). Between July 1991 and March 1992, sludge was disposed off illegally within the floodplain of the Isipingo River, just ahead of the DWS (Rankin, 1992).Surveys undertaken by Umgeni Water in the late 1980's also attest to the poor quality of water of the lower reaches of the Isipingo River.

Total phosphate and suspended solids levels were found to be exceeding the standards set by the Department of Environmental Affairs at most of the sampling sites monitored by Umgeni Water (Kalicharran and Diab, 1993). According to Ramm (1987), the survey conducted by the Council for Scientific and Industrial Research (CSIR) in August 1985, the dissolved oxygen levels in the Lagoon at the surface and the bottom was approximately 6 ppm which is considered to be about 50% saturation. At the Southern Arm, dissolved oxygen has always been present in surface and bottom water (Begg, 1978; Forbes and Demetriades, 2008). According to Philip (2010), the bottom sediment along the mangrove area (i.e. near the northern arm) consists largely of sludge which leads to the creation of an anoxic zone. The northern arm was 'virtually devoid of oxygen' although at times, due to algal blooms, the surface water became super saturated, whilst the bottom water remained anoxic (Begg, 1978; Forbes and Demetriades, 2008). The estuary is characterized by the accumulation of very fine, soft anaerobic material in the mid and upper reaches and the sediment contains high metal concentrations including iron, mercury, lead and zinc (SSI, 2011). There has also been an increase in the frequency of fish kills at the Lagoon area which has been attributed largely to sewage overflows as a result of pump station failures, breaks in the sewer lines and blocked manholes **(**Philip, 2010). The water quality upstream of the sluice gates is also considered unacceptable (Forbes and Demetriades, 2008).

Conclusion

Land use changes in the Isipingo catchment has contributed directly to the degradation of a once thriving and healthy ecosystem. The diversion of the Umlazi River and the development of the DWS which enabled industrial and residential development within the floodplain of the Isipingo River have resulted in a 97% reduction in flow to the Isipingo Estuary system and the inability of the system to maintain its natural connection with the marine environment. This resulted in the construction of twin pipes to maintain this connection. Infilling of land for urban and industrial development within the floodplain of the system has resulted in the loss of wetlands, mangroves, coastal forest and riparian vegetation. The deterioration in water quality of the system has been attributed to reduced flow (providing less dilution), malfunction of sanitation systems and illegal discharges into the system. The deterioration of Isipingo system demonstrates the consequences of improper planning, decision making and regulation with respect to the environment.

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