IMPACT OF INDUSTRIAL AND MUNICIPAL WASTE-LOAD ON SKINNERSPRUIT IN GAUTENG PROVINCE, SOUTH AFRICA

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ABSTRACT

South Africa's semi-arid climate makes surface water a highly valued resource for the country. Typical of many developing countries, however, surface water quality is often lowered because of effluents which are discharged into nearby rivers, streams and lakes. In Gauteng Province, South Africa, Skinnerspruit is an important water body which flows eastwards from Hartbeerspoort (a lake in West Pretoria), and flows approximately parallel to the Magalies Freeway, passing through both residential and industrial estates in the capital city. It therefore serves as a sink for industrial and municipal effluent discharges which take place daily. Field sampling studies conducted on Skinnerspruit (as well as two canals that deliver effluents from industrial and residential estates into Skinnerspruit) in January and June focused on faecal coliform, dissolved oxygen (DO), and nitrate/nitrite as nitrogen. Other tested parameters included chemical oxygen demand (COD), pH, total suspended solid, and temperature. Some of the results showed that faecal coliform in the river had mean values of 111,444 upstream (U/S) and an attenuated mean value of 3,607 cfu/100 ml downstream (D/S). However, DO had mean concentration of 7.24 mg/l U/S but an improved value of 7.75 mg/l downstream. pH improved marginally from its alkaline state of 8.18 U/S to 8.13 D/S. Temperature also improved marginally from 17.55°C U/S to 17.04°C D/S. Nitrate worsened from to 1.31 to 3.19 mg/l D/S. COD improved from 27 to 20.11 mg/l. These results indicate that Skinnerspruit is heavily polluted, especially from faecal coliform. However, the river is responding positively through natural attenuation processes.

Keywords: river, pollution, municipal waste, effluent, attenuation, dissolved oxygen.

1 INTRODUCTION

Rivers serve diverse important functions for society, inclusive of water supply, transportation, recreation, food production, flood conduit, and sinks for effluent discharge from municipal and industrial activities [1], [2]. These functions of river systems are invaluable contributions to the sustenance to modern society and civilization. The river ecosystem, however, needs to be monitored and protected to ensure it continuous to serve its purpose sustainably. A river has capacity to take up waste matter and break it down over time, before returning to its original state [3]–[5]. However, this capacity is contingent on a variety of physical factors, including the need to monitor and control waste-loads, so that the natural capacity of the stream to break down foreign matter is not exceeded [3]. However, this is not always the case as rivers are relentlessly loaded with waste matter as a consequence of modernization, industrialization and national development [6].

South Africa has a rich network of surface water bodies, which includes several rivers. These surface water bodies constitute valuable natural water resources to a water-stressed nation [7]. South Africa is the 29th driest country out of 193 countries ranked with respect to total available fresh water resources per capita [8]. South Africa's freshwater resources serve a variety of purposes with 62% going into agriculture; 27% to domestic, municipal, and industrial uses; and 3% to ecological conservation purposes [9]. The foregoing facts makes

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it necessary to protect every available freshwater resource in the country. Therefore, the aim of the current research was to measure and monitor the concentration of pollutants being discharged into Skinnerspruit, a river that runs through commercial, industrial and residential districts of the City of Tshwane Metropolitan City [10], in order to determine the possible impacts of the pollutants on the river.

2 METHOD AND MATERIALS

2.1 Study area

Skinnerspruit originates from Hartbeerspoort and travels nearly parallel to Magalies Freeway till it merges with Apies river, approximately 30km (as the crow flies) at Pretoria central (Fig. 1). Pretoria is a major industrial centre with pockets of industrial estates situated around the city [10]. Skinnerspruit path crosses industrial and residential areas, thus making it susceptible to waste discharges from both areas. The Kwagga (S1) and Transoranje (S2) areas consists of several industries as well as residential areas, while Rebeccastraat (S4) is mostly residential. Zeilerstreet Canal (S3) carries residential wastes which empties into Skinnerspruit (Fig. 1). Shortly after S5, Skinnerspruit merges with Apies river near Pretoria Central (Fig. 1).

Water samples were taken along Skinnerspruit at S2, S4, and S5, while run-off draining from Kwagga into a canal was sampled at S1 and residential effluent draining through a canal into Skinnerspruit was sampled at S3 (Fig. 1). All samples were obtained between 0800 and 1000 hours. Grab samples were collected at each sampling point in January and June. South Africa has four seasons, Summer, Autumn, Winter, and Spring [11]. The samplings were designed to occur in the extreme seasons (Winter which peaks in June and Summer/rainy season which peaks in January). The summer is characterized by slight rainfall while winter is characterized by zero precipitation. Temperature ranges between 21^{o}C to 27^{o}C in the rainy season (Autumn and Summer or August and January) and between 8^{o}C to 15^{o}C in June [7].

2.2 Sampling and sample analysis

Physical parameters such as dissolved oxygen (DO), total suspended solids, pH, and temperature were determined in-situ using a hand-held HACH HQ40d portable meter which has an IntelliCAL probe. Chemical and biological contaminants were however determined by analyses of grab water samples which were transported to Daasport Wastewater Treatment Plant (DWTP) laboratory. Two batches of water samples were obtained for the laboratory analyses. The samples for chemical analyses were collected into 2-litre polyethylene bottles. The samples for determination of faecal coliform, however, were collected in 250 ml bottles and hermetically sealed. All samples were transported to the laboratory within an hour of sampling and analyses done upon arrival at the laboratory. COD was determined using titrimetric method and nitrate was determined using Hach UV screening model DR 6000. Faecal coliform was determined using spread plate method.

3 RESULTS AND DISCUSSION

The data for January and June are presented in Tables 1 and 2. The data in Table 1 shows that a high concentration of faecal coliform is discharged from the storm canal at Kwagga road (S1) and the Zeiler street canal (S3) into Skinnerspruit. This faecal coliform load however became greatly attenuated by 87.94% at S1 and 99.53% at S3 in June at the peak of winter (Table 2). This reduction is attributable to the ambient temperature drop which is unfavourable to the bacteria, which is in tandem with the study of Lonsane et al. [12].

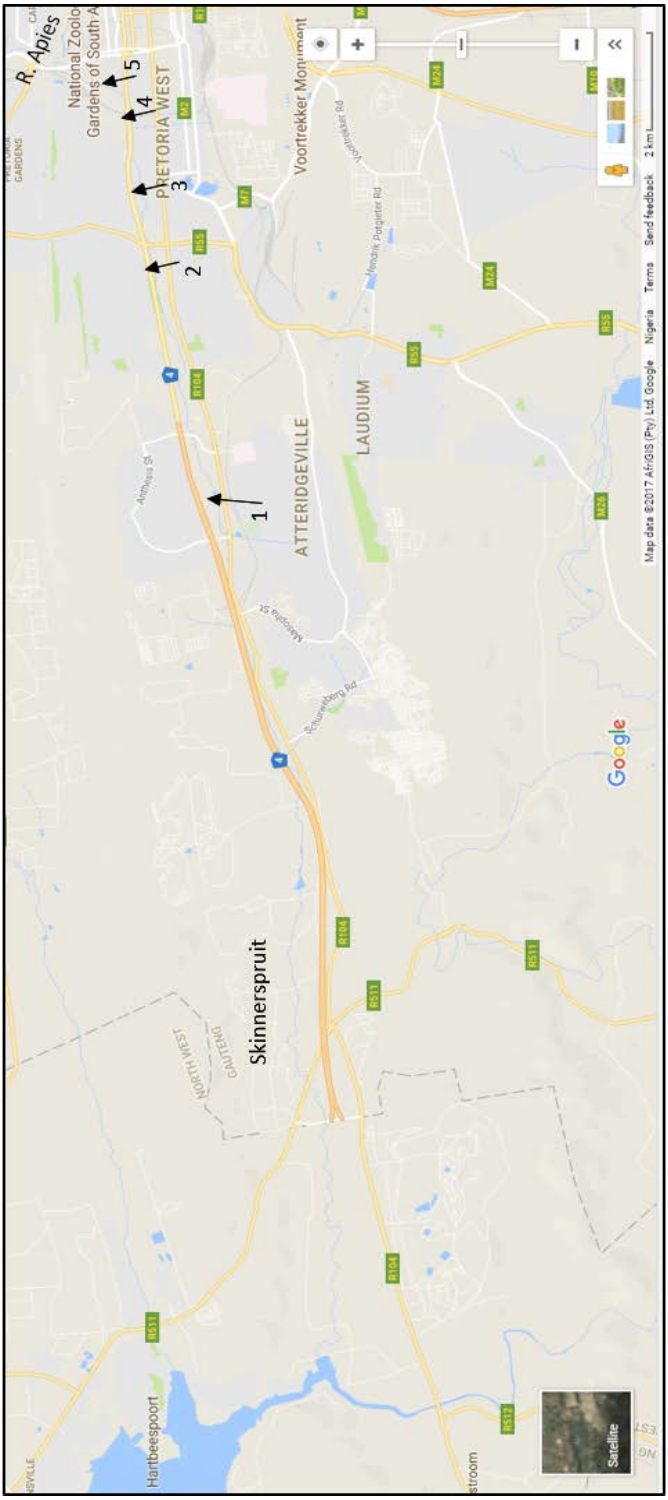

Figure 1: Outline of Skinnerspruit and sampling locations. (*Source: edited Google map.*)

Table 1: Result of analysis for January.

Sampling station	Description	COD (mg/l)	DO (mg/l)	Faecal coliform (cfu/100ml)	(NO_2+NO_3)-N (mg/l)	TSS (mg/l)	pH	Temp (ºC)
1	Storm water canal from PMP next to Kwagga Road	20	4.35	34,000	0.76	7.4	7.69	22.8
2	Skinnerspruit at Transoranje road	16	7.19	7,000	0.98	12.2	8.15	22.2
3	Zeilerstreet Canal before Skinnerspruit	28	7.85	320,000	0.96	11.8	8.51	24.5
4	Skinnersruit at Rebeccastraat in Vom Hagen Street	14	7.61	4,000	1.59	10.2	8.23	24.5
5	Skinnerspruit at Premos before Apies Confluence	40	7.43	34,000	1.32	5.4	8.2	21.3

Table 2: Result of analysis for June.

Sampling station	Description	COD (mg/l)	DO (mg/l)	Faecal coliform (cfu/100ml)	(NO_2+NO_3)-N (mg/l) (mg/l)	TSS (mg/l)	pH	Temp (ºC)
1	Storm water canal from PMP next to Kwagga Road	16	5.82	4,100	0.98	12.4	8.96	13.41
2	Skinnersruit at Transoranje road	26	8.37	100	0.64	2	8.16	8.84
3	Zeilerstreet Canal before Skinnerspruit	32	7.73	1,500	1	2.4	8.22	14.73
4	Skinnersruit at Rebeccastraat in Vom Hagen Street	42	9.02	7,800	1.79	3.6	8.22	12.14
5	Skinnerspruit at Premos before Apies Confluence	24	7.34	37,000	1.47	0.4	8.2	8

Similarly, dissolved oxygen content of the river improved in June by 33.79% at S1 and 1.53% at S3. This is also in agreement with the study carried out by Omole et al. [3], [9] which shows that DO level of running streams improves with lowered temperature, among other factors. Conversely, Nitrate and Nitrite content of the effluent samples (measured as Nitrogen, N) increased during the winter in June (which is characterized by lowered temperature) by 28.95% at S1 and 4.17% at S3. According to Kim et al., [13] the oxidation rate of ammonia and nitrate increases with temperature rise. This means that when temperature is lowered, oxidation rate is reduced, and less nitrogen is produced, thereby leading to accumulation of nitrite and nitrate in the canals. The pH readings also indicate that both the effluent from the canals and water from the river are alkaline (Tables 1 and 2). Akaline water provides enabling environment for some alkaphilic bacteria and may make other bacteria grow some resistance [14], thereby altering the ecological landscape of the area. Temperature naturally responded to the seasons (winter and summer with generally lowered temperatures in June (Tables 1 and 2).

3.1

3.1 DO, nitrate, nitrogen, and TSS trend along Skinnerspruit

Like what took place in the canals, DO level of the river increased in June above the DO level in January (Figs 2 and 3). Also, the river continued to be attenuated with respect to DO level, despite waste-loads from both canals (S1 and S2). The DO level increased but took a downturn after S4 (Fig. 3). This may be connected to increased pollutant load in the stream from other unidentified point and non-point sources of pollution along the river. The total suspended solids (TSS) was gradually and progressively attenuated between S2 and S5 in January as well as June. Nitrate and nitrite levels in the river was lower in winter (June) than in summer (January). This is the reverse of what occurred in the canals (Tables 1 and 2). This means that the complete oxidation of nitrogen compounds in the river was higher than in the canal. The complete oxidation of nitrite in the river could have been aided by velocity of the stream [15]. When the stream body velocity is increased, turbulence is introduced, thereby aiding oxidation. Moreover, the capacity of water to absorb DO is inversely proportional to temperature increase [15].

3.2 Faecal coliform trend along Skinnerspruit

The faecal pollution load on Skinnerspruit had a similar trend of progressive increment, both in January and June (Fig. 4). However, there seems to be no correlation between the faecal coliform load in the canal (which is being emptied into the river) and the faecal loading pattern in the river itself. In January, the faecal load in the river at S2 is lower than that at S1 (canal) (Table 1). This shows that the pollution had been abated between S1 and S2. Similarly, in January, the faecal load from the canal at S3 had been abated at S4. The sudden rise in faecal load at S5 therefore suggests that although the stream naturally attenuates the waste-loads, other unidentified sources continue to pollute the river downstream of the canals, between S4 and S5 (Table 1). A similar situation is repeated in June, thus confirming there is an independent pollution source along Skinnerspruit. A study of the map of Pretoria shows that at Pretoria Central, several peri-urban settlements surround Skinnerspruit. Such settlements contain markets, abattoirs and shanties where uncontrolled pollution activities might emanate.

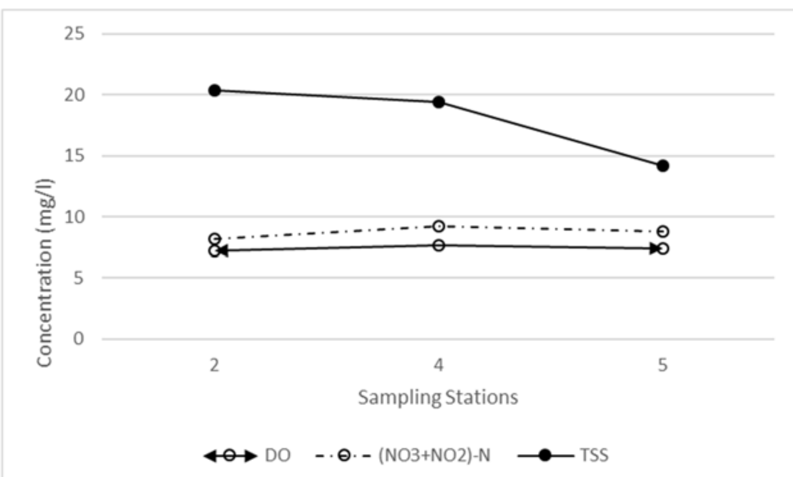

Figure 2: Trend of DO, (NO3+NO2)-N, and TSS in January.

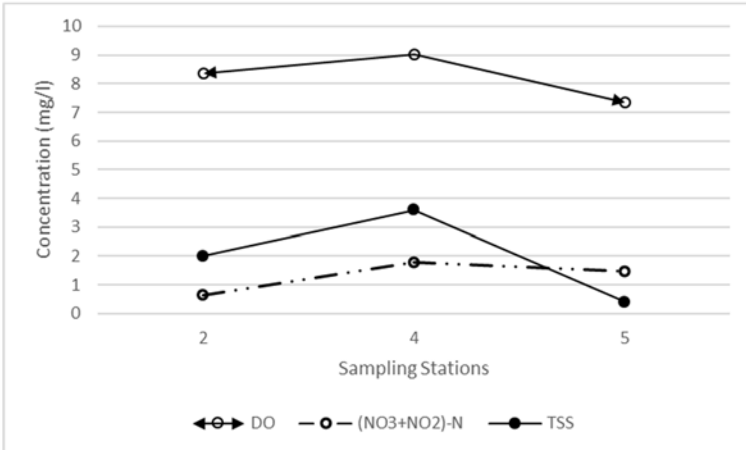

Figure 3: Trend of DO, (NO3+NO2)-N, and TSS in June.

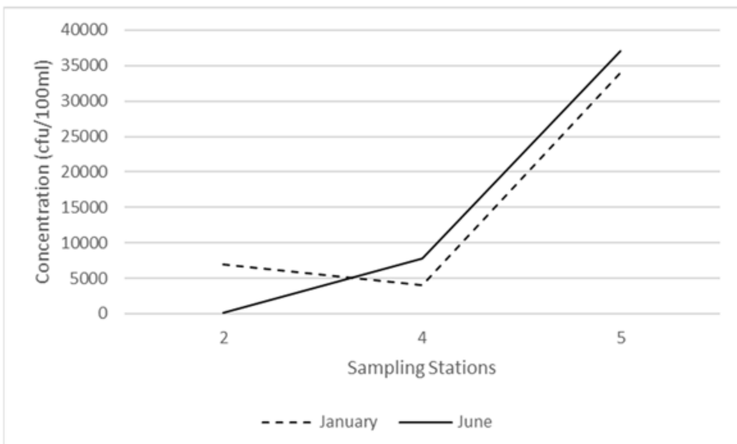

Figure 4: Trend of faecal coliform along Skinnerspruit in January and June.

3.3 COD trend along Skinnerspruit

Chemical oxygen demand (COD) is a measure of inorganic pollutants that might be present in effluents [16]. Data (Tables 1 and 2; Fig. 5) indicates that the highest levels of COD were found in portions of Skinnerspruit which traverses Pretoria Central area (S4 and S5). This, again, points to the fact that commercial activities and pollution from shanty dwellers in the area might be responsible for the heightened COD loading in the river.

4 CONCLUSION AND RECOMMENDATION

The current study considered the pollution trends along Skinnerspruit in both summer and winter seasons *vis-a-vis* waste-loads into the river from two major canals in the city of Pretoria. It was observed that although the canals contributed high concentrations of

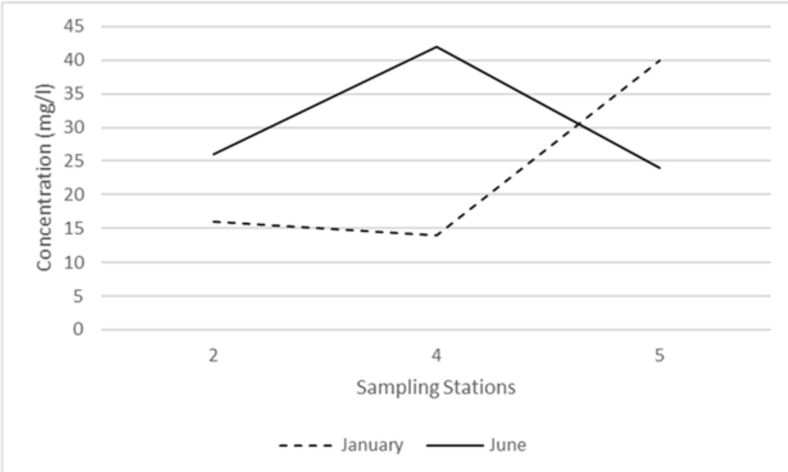

Figure 5: Trend of COD along Skinnerspruit in January and June.

pollutants into the river, the river responded well to the pollutants from the river. However, pollutants at the latter portions of the studied segments along Skinnerspruit suggested the presence of other unidentified contributors of pollution to the river. It is therefore recommended that regulatory authorities investigate the activities taking place between Vom Hagen and Premos in Pretoria Central, with the aim of arresting any pollution trend that could jeopardize environmental integrity and public health.

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