Assessing the human and drought influences on the Kruger rivers using SASS5 and water quality indices

– 2018 Report

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Summary

The downstream location of the Kruger National Park compels the park to conserve rivers with ecosystems that have different degrees of degradation from human activities upstream. The conditions of these systems are now further complicated by the current drought that is expected to also influence them. In order to determine the human and drought impacts amongst these rivers, we sampled macroinvertebrates guided by SASS5 sampling protocol and also recorded water quality data for a period of 8 years (2010 to 2018). In this report we present the SASS5 and water quality data and compare the current drought season (2018) to the previous ones. Indices from both SASS5 and water quality do confirm that rivers perceived to be highly impacted (notably the Olifants) have inferior macroinvertebrates and water quality results than the Sabie and the Luvuvhu. We also use these indices to determine if the current drought influences these ecosystems. It seems as if the drought affects these rivers indiscriminately of the status of their human degradation. The Sabie and the Letaba seem to be impacted by the drought while the Luvuvhu is not much affected. The human impacts seem to be more influential than the drought in the Crocodile and the Olifants. The 2018 SASS5 index statuses vary amongst rivers. The Crocodile and the Letaba are lower than previous years while the Sabie is average. The Olifants and the Luvuvhu are better than their previous seasons with the Luvuvhu having best indices since the inception. There is an improvement in the water quality indices in all the rivers in 2018 except the pH values that were all more alkaline than in previous years.

Introduction

The Kruger National Park (KNP) is located downstream of the five perennial rivers. These five rivers are exposed to different human induced impacts before they flow through the Park then into Mozambique. As a result, the Park cannot effectively protect the rivers from human disturbances they are exposed to upstream. Because of their latitudinal locations, these rivers experience different degrees of human disturbances influenced by the type of land-uses and settlements they flow through. Sabie and Luvuvhu rivers are less impacted as they flow through areas with less industrial and human-settlement activities and we here forth call them 'less-impacted rivers'. Crocodile, Olifants and Letaba are most impacted rivers mainly by nitrification and acidic waters from upstream farming and mining activities, and are here forth called 'degraded rivers'. The lack of perennial tributaries, within the park, of all these rivers further more makes the park less effective to ameliorate such disturbances inside the park. Water use in the catchments of all these rivers, except for the Sabie River, had exceed the available water and the set Ecological Reserves (DWAF 2004a,b,c; DWAF 2009; Pollard *et al.* 2010).

In addition to the anthropogenic disturbances these rivers endure, they also experience natural disturbances – notably the floods and droughts – that are natural drivers of the ecosystems in the southern African region (Mawdsley et al., 2016). Recently we have been experiencing drought (Swemmer et al., 2018). We therefore expect that the river flows will decrease and consequently dry up some of the marginal vegetation. We are also expecting that salinity in the water of these rivers will also increase due to the decreased volumes of the discharged waters that dilute them.

SANParks has implemented ecological monitoring projects in these rivers to get empirical information that will help the park to understand both the human and natural influences in these river systems. Through such projects SANParks can make informed decisions and execute mitigations to conserve these ecosystems. These projects include macroinvertebrates as indicator organisms or responders that can be measured against variables influencing the river ecosystem such as water flows and water quality. Sampling has been conducted since 2010 during the dry season when these rivers are most vulnerable for human activities.

Although we have stated the drought impact we are expecting, we are however not certain if the drought is intense enough to cause significant impact, or if the river ecosystems are vulnerable enough to show big impact as this is the first drought cycle since we implemented the monitoring project. We also do not know if the drought impact will be further exacerbated by the anthropogenic stresses these rivers already experience. We are uncertain if the impact will be more pronounced in the degraded rivers (viz. Olifants, Crocodile and Letaba), or in the less-impacted ones (viz. Sabie and

Luvuvhu), or in the vice versa. The current drought is therefore providing opportunities to learn how rivers with different human impacts respond to the droughts.

We therefore present the temporal and spatial comparisons amongst these five rivers from 2010 to 2018 where we compare macroinvertebrates and water quality variables sampled to determine if human activities and drought affect these river ecosystems.

Material and Methods

We sampled and identified macroinvertebrates following the South African Scoring System Version 5 (SASS5) as stated by Dickens and Graham (2002) using its three indices (viz. number of families, SASS Score and Average Score Per Taxa (ASPT)) for each site of a river. Families sampled for all sites of a river were then combined to get total number of families for the river. The quality scores of these families were then combined to get the SASS Score and ASPT for the river as a whole.

In each site the pH meter was used to measure the acidity and alkalinity of the river water. A conductivity meter was used in each site to measure the concentrations of ions from dissolved salts and other inorganic materials (such as alkalis, chlorides, sulphides and carbonates compounds) in micro-Siemens. A TDS meter was used in each site to measure the concentration of dissolved solid particles such as salts and minerals in milligrams per litre (mg/L). The salinity meter in parts per million (ppm) was used to measure the concentration of dissolved salts in water. We calculated and used the median value of each variable from all the sites of the river, and was used it to represent the river as a whole.

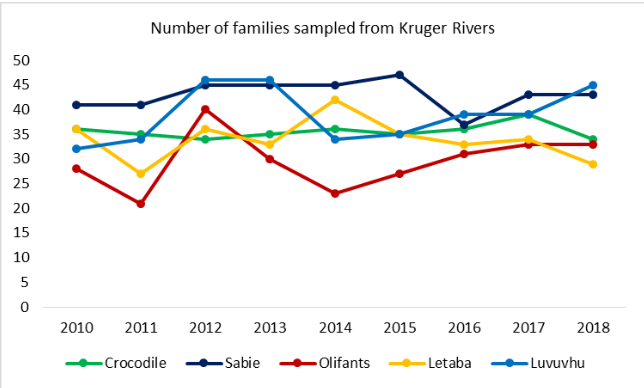
We then compared these indices amongst the rivers where the Sabie and Luvuvhu indices (rivers with low human impacts) were compared to indices of the Crocodile, Olifants and Letaba (relatively more impacted rivers) to determine if there are clear human impacts in these systems.

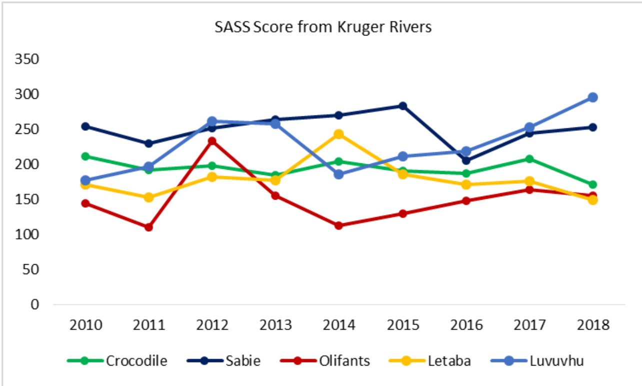
We regarded the 2010 to 2013 as a non-drought period, and the 2014 to 2018 as a drought period to determine the influence of the drought to the Kruger rivers. We then compared the indices between these two periods to determine the drought impact for each river.

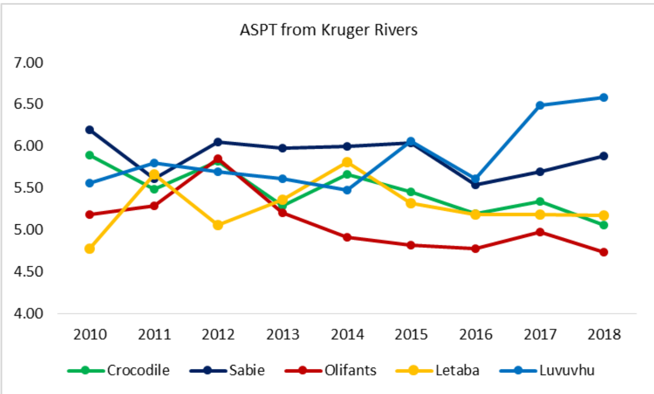
Results and Discussion

Human Impact:

Historically (from 2010 to 2018) the less-impacted rivers (*videlicet*, the Sabie and the Luvuvhu) frequently had more families, higher SASS5 score and better ASPT than the degraded rivers (viz. Crocodile, Olifants and Letaba) (figures below). The long-term median family number of the Sabie is 1.4 times more than that of Olifants while the SASS5 score of the Luvuvhu is almost 1.5 times better than that of Olifants. Sabie also has an ASPT long-term median that is 1.2 times more than Olifants'.

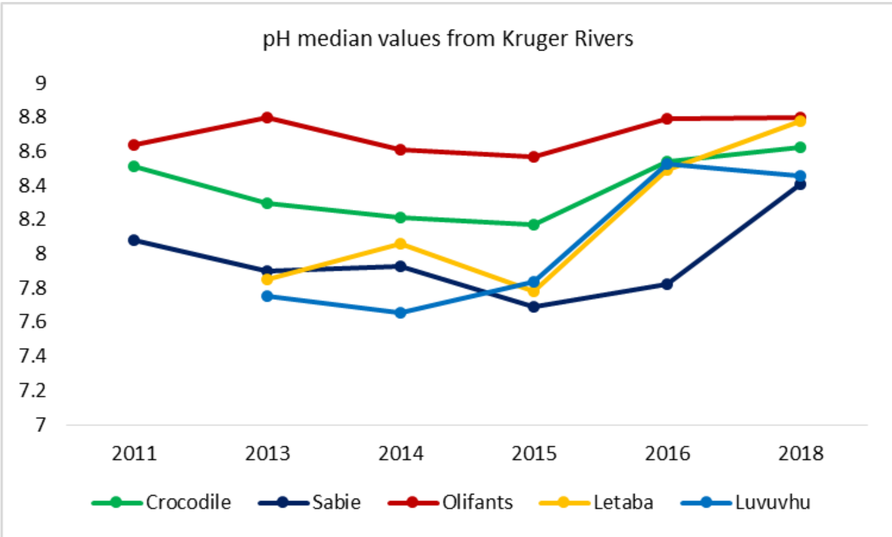




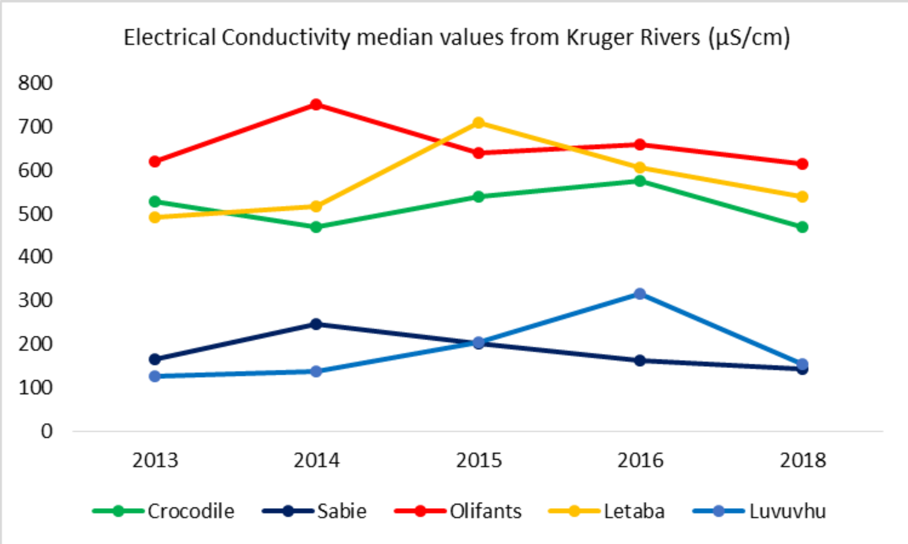


The SASS5 indices confirm the view that some of the Kruger rivers have degraded ecosystems which we attribute to the human activities these rivers endure. The indices show that the Olifants is the most degraded river, and this indication is accordance to expectation.

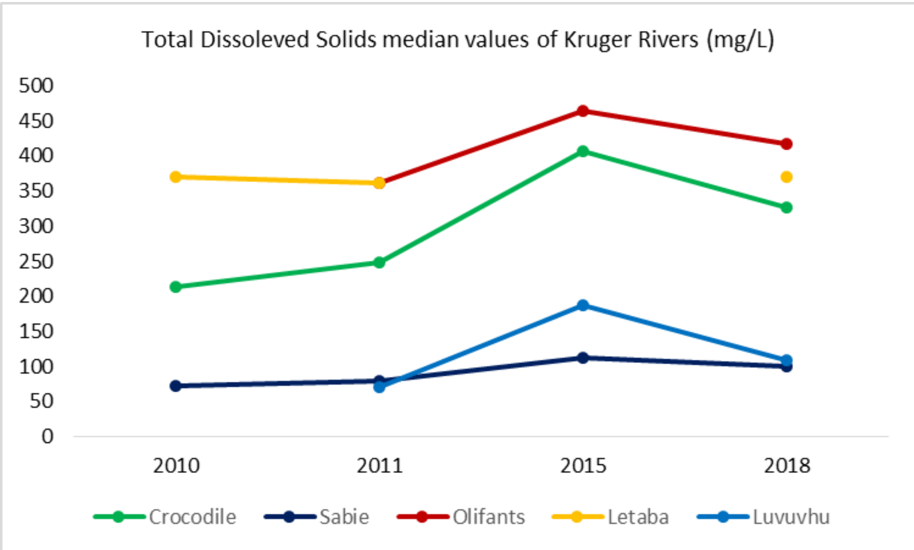
Although all the rivers are within the optimum pH levels of 6.5 to 9.0, for the general aquatic organisms (Fondriest), the pH values of the less-impacted rivers are frequently at the alkaline ranges that are closer to the neutral point of the pH scale (7.66 to 8.46) (figure below). The waters of the degraded rivers are frequently at the alkaline rangers that are relatively higher and further from the neutral point (7.78 to 8.78) – with the Olifants always been the furthest (8.57 – 8.8). The further pH values (from the neutral point) of the impacted rivers could be impacting sensitive macroinvertebrates species (Fondriest). We therefore suspect that high pH levels might be above pH tolerance levels for developmental stages of some sensitive species.



The electrical conductivity (EC) measurements show that the degraded rivers are three times higher than the less-impacted ones (figure below). They range from 470 to 750, with the Olifants being the highest and four times higher than Luvuvhu's. Their ECs are most frequently beyond the 150 to 500 range that is optimum for the freshwater ecosystems (Water Quality Field Guide). The ECs of the less-impacted rivers are within the optimum levels and they range from 126 to 316 µS/cm. We suspect that the elevated EC in the degraded rivers is mainly due to the anthropological activities upstream. These high values could be harsh to some stages of sensitive species, and therefore contribute in the absence of such species in the systems.



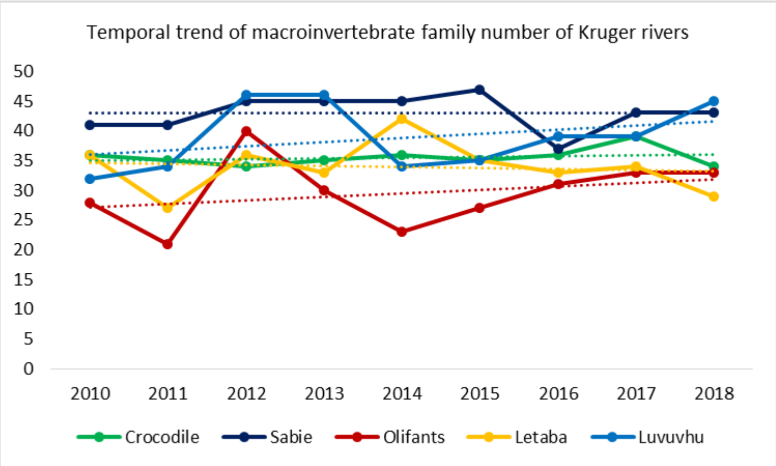
The concentrations of the inorganic salts (known as Total Dissolved Solids (TDS) in all the impacted rivers are higher than in the less-impacted ones (figure below). They range from 214 to 465 mg/L, with the Olifants being the most concentrated and four times higher than the Sabie. Other studies have reported that the minimum TDS concentrations start to be toxic to some invertebrates from the 814 mg/L (depending of the combination of the solids) (Weber-Scannell & Duffy, 2007). Although the concentrations of the Kruger rivers have been below the toxic levels, the degraded ones are most frequently beyond the 280 mg/L concentrations that Weber-Scannell & Duffy (2007) reported to be toxic to some species of planktonic animals that are sources of food to macroinvertebrates and fish. The TDS concentrations at the less-impacted rivers range from 72 to 184 mg/L which is below the toxic concentrations of recorded TDS even for planktonic animals. We suspect that the high TDS concentration in the degraded rivers is toxic to sensitive macroinvertebrates, and thus contribute to their absence in such systems. We also think that these concentration level are mainly due to the anthropological activities upstream of the park.

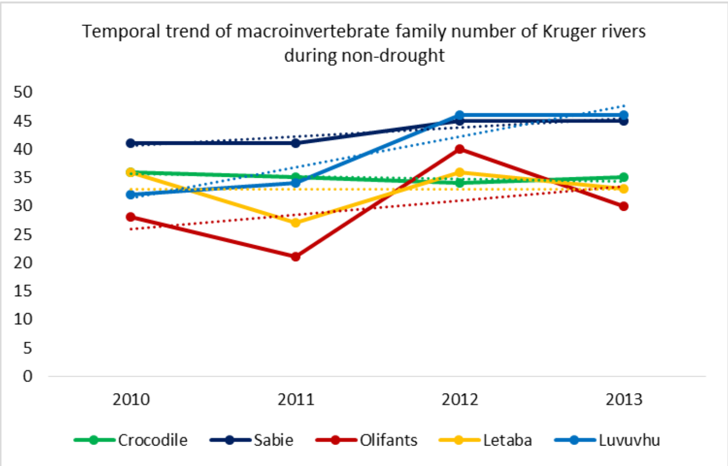


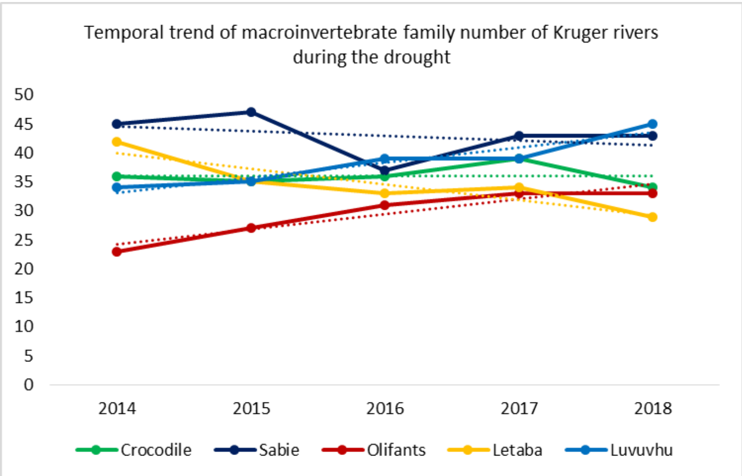
Both SASS and water quality indices show that the human activities beyond the park are attributed to the corrosion of the river ecosystems, mostly of the degraded rivers and the impact is escalating to the park. Water quality data furthermore show that there is no spatial improvement at all the Kruger rivers inside the park. This could be attributed to the lack of perennial tributaries inside the park that could ameliorate such impacts. This also makes the Kruger rivers vulnerable to the upstream activities.

Drought Impact Assessment:

<u>Family Numbers:</u> There is no clear temporal trends on the family numbers in the Crocodile, Sabie and Letaba rivers for the entire monitoring period (from 2010 to 2018). We however observed a positive trend in the Olifants and Luvuvhu (figures below). There was also a positive trend in the Crocodile, Sabie, Olifants and the Luvuvhu during the non-drought period (2010 – 2013), and not clear in the Letaba. The Sabie and Letaba reflected a negative trend during the drought period (2014 – 2018) but the Olifants and Luvuvhu rivers reflected a positive trend. The pattern was not clear in the Crocodile.



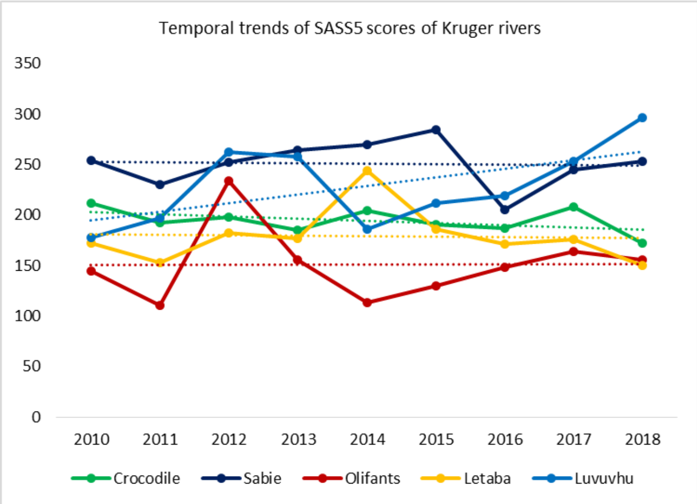


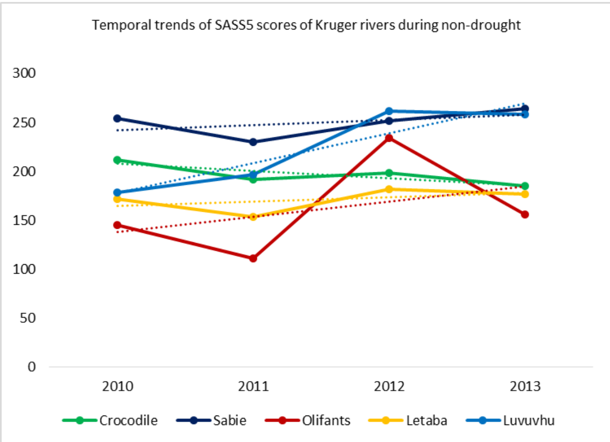


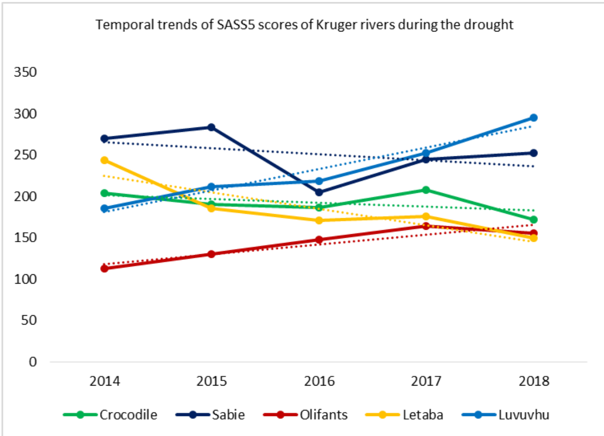
The temporal trend analyses show that the family numbers of the Sabie and the Letaba are more negatively impacted by the drought than the other rivers. Their families were increasing during the non-drought years and then started declining during the drought (particularly in the Sabie). The low flow in 2018 in the Letaba, resulted in no sampling site at the Klipkoppies site because there was no water flow. The Confluence site had no surface water at about six meters from where it confluences into the Olifants. We experienced or observed such flow conditions for the first time at these sampling sites (Klipkoppies and Confluence) since the inception of the project. The number of families at the other rivers are not affected by the drought, especially the Olifants and the Luvuvhu where they are still increasing.

Very low flowing Klipkoppies (left) and the non-flowing Confluence (right) sites of the Letaba River during the 2018 sampling.

SASS Score: There was no clear trend on the SASS Score in the Crocodile, Sabie, Olifants and Letaba for the entire monitoring period (from 2010 to 2018). The score was declining in the Crocodile and increasing at the Luvuvhu during this period (figures below). During the non-drought period (2010 – 2013) the scores of Sabie, Olifants and the Luvuvhu were increasing, and did not change much in the Letaba. SASS Scores declined in the Crocodile. During the drought period (2014 – 2018) the scores also declined in the Crocodile, Sabie and Letaba but they increased in the Olifants and Luvuvhu.

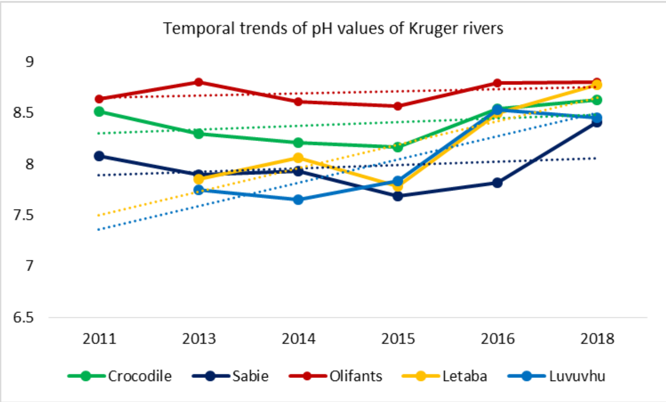


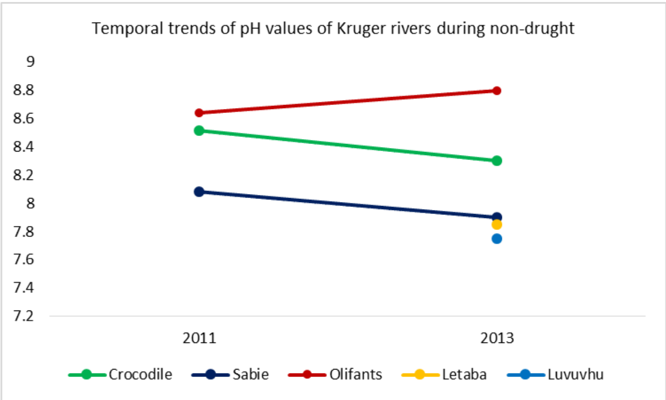


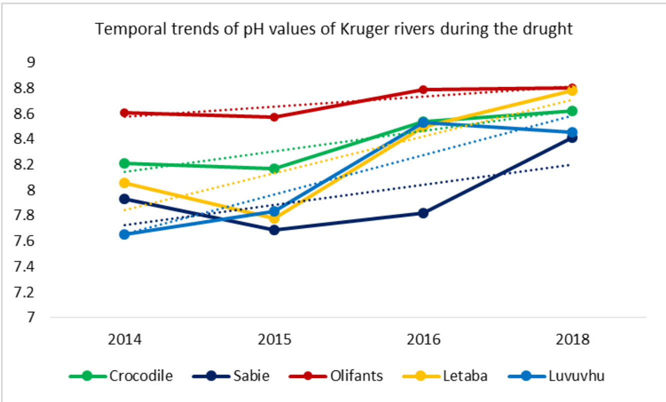


SASS scores show that the Sabie and the Letaba rivers are most negatively impacted by the drought because they started experiencing the decline only during the drought. The impact was more prevalent in the Sabie where sensitive macroinvertebrates families (with SASS5 score of 12 to 15) started to decline at this drought period. We suspect that there are other factors besides the drought that could be driving the decline in the Crocodile because it started declining before the drought. The Olifants and the Luvuvhu seem not to be affected by the drought because their SASS score still increased during the drought.

pH: The temporal trend analyses show that the pH levels of all the rivers have been increasing during the entire monitoring period (from 2010 to 2018)[1] (figures below). During the non-drought period (2010 – 2013) they were decreasing in the Crocodile and Sabie, and increasing in the Olifants. The Letaba and the Luvuvhu were only sampled for us to do a proper assessment. The pH levels of all the rivers were increasing during the drought period (2014 – 2018).



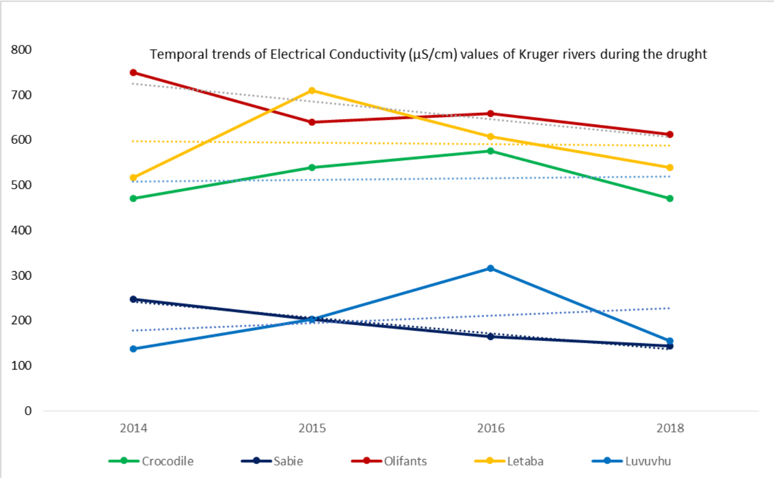




The increase in the pH levels of all these rivers does show that the drought affected the rivers. However, the Olifants shows that its pH had been increasing before the drought. We suspect this increase is mainly driven by anthropogenic activities.

[1] The data of most of the water quality indices were infrequently sampled when equipment was available from external partners.

Electrical Conductivity: We only have EC data for 2013 to adequately assess the trends during the entire monitoring period (from 2010 to 2018) and the non-drought period (2010 – 2013). For the drought period (2014 – 2018), the trends are positive at the Crocodile, Letaba and Luvuvhu rivers, and negative in the Sabie and Olifants (figure below).



The increasing trends in the Crocodile, Letaba and Luvuvhu rivers is in accordance to our expectation that the low flows due to the drought will influence the levels of their EC. We are however uncertain what might be driving the decrease in EC of the Sabie as it is contrary to our expectations. We suspect that the decrease in the Olifants is mainly driven by anthropogenic activities than being mainly influenced by the drought.

TDS: Due to the inconsistent availability of equipment, the TDS data have been sampled infrequently at different rivers and years to get reliable temporal trend analyses.

2018 Status

The 2018 SASS5 indices of the Crocodile and Letaba were worse than the previous years, and below the long-term median points. However, indices for the Sabie were mostly at the median points. The Olifants indices were mostly above median points while Luvuvhu had the highest since the inception of the project. The median pH values of all the rivers were above their long-term median points and were most alkaline (except in the Luvuvhu) since inception of the project. The TDS median values for the Crocodile and the Sabie were within their long-term median points, while the Olifants and the Luvuvhu were above their long-term median points. No previous data was available from the Letaba to do comparison. The conductivity median values for the Crocodile, Sabie and Olifants were below the long-term median points while the Letaba was above long-term median points. The conductivity at Luvuvhu was within its long-term median point.

Conclusion

The human activities upstream of the Kruger rivers impact them with different degrees of degradations. The current drought increased the levels of variables which result in degraded river water quality and depressed macroinvertebrates communities. We however suspect that the drought is affecting these rivers differently. Water quality impact was more prominent in the Sabie and Letaba, and less so in the Luvuvhu. This further highlight that the two less-impacted rivers are affected differently by the drought. We attribute their difference to the intensity of the drought that we think is not as high in the Luvuvhu catchment as it is in the Sabie. We however think that the anthropogenic activities are influencing the conditions of the Crocodile and Olifants than the drought. We are aware that riverine ecosystems are complex and they are driven by many factors such as habitats and water flows – that we did not assess.

Acknowledgments

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