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SEASONAL VARIATIONS IN TURAG RIVER WATER ALKALINITY

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ABSTRACT

Rivers in Bangladesh play a very important role in the life and economy of the country. Even though several key parameters of rivers are usually measured to adjudge the quality of rivers, alkalinity has been neglected in the routine measurement of river parameters. Alkalinity levels are important because they buffer acidic rain and acidic wastes and high alkalinity in river water can cause the change in the dynamics of chemical processes in the rivers. This paper reports the seasonal changes in the alkalinity of Turag, a commercially important river in Bangladesh on the banks of the capital Dhaka. The results shows that overall alkalinity in the river is high due to the higher level of bicarbonate contaminations and the discharge from industries including untreated wastewater. There is no carbonate in water, but bicarbonate is very high specially at locations near the concrete and cement factories which opens up the possibility that the chemistry of urban streams is modified by the leaching of minerals from concrete infrastructure. This has far reaching consequences for the amount of alkalinity in rivers and its potential impact on the environment.

KEY WORDS: River pollution, Turag river, Alkalinity, Bicarbonate, Concrete industry

INTRODUCTION

Bangladesh contains the world's largest river delta affecting the lives of more than 100 million people living in the country (Pakulski, *et al.,* 2021). The water quality of the rivers has considerable environmental importance as it serves as the primary source of drinking water, agriculture, hydroelectric power plants, transportation, tourism, recreation, and others (Halder and Islam, 2015). Turag, one of the most polluted rivers in the urban area of Dhaka city, is in the upper tributary of the Buriganga, a major river in Bangladesh. The Turag originates from the Bangshi River, an important tributary of the Dhaleshwari River, flows through Gazipur and joins the Buriganga at Mirpur in Dhaka District (Khan, *et al.,* 2020). Previous studies on Turag in Bangladesh have shown that the location of industries and agricultural runoff play an important role in river water quality (Khan, *et al.,* 2020). It is thought that the water quality of Turag is greatly impacted by different industrial discharges including organic and inorganic effluents that interact with river water (Aktar and Moonajilin, 2017). This discharge imposes adverse impacts on the livelihood of the local community, adjacent landmass, and aquatic ecosystem. (Begum, *et al.*, 2018). In September 2009, the Department of Environment (DoE), Bangladesh, declared the Turag River to be in an ecologically critical condition based (ECA) on the heavy pollution discharged by the industries in the area (DoE, 2010).

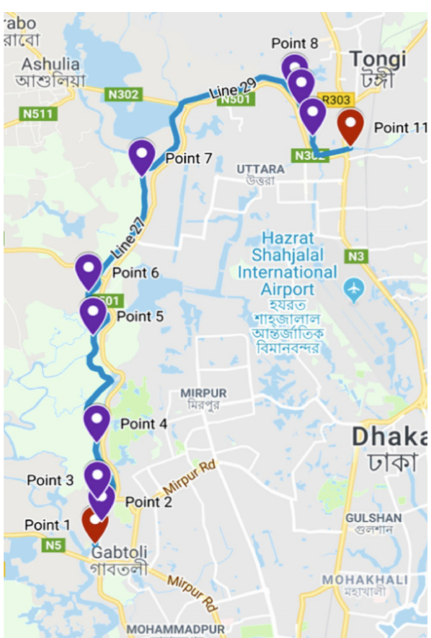
Alkalinity, an important water quality parameter is a measure of how much acid can be added to a liquid without causing a large change in pH which is measured by using phenolphthalein (p Alkalinity) and methyl orange (m Alkalinity) indicator. The main difference between p Alkalinity and m Alkalinity is that p Alkalinity is the measurement of alkalinity given by hydroxide (OH^-) ions and half of the carbonate (CO_3^-) alkalinity whereas m alkalinity is the measurement of alkalinity given by hydroxide ions (OH-), carbonate (CO_3^-) and bicarbonate (HCO_3^-) alkalinity (Ibanez, *et al.*, 2008). Higher alkalinity levels in surface waters buffer acid rain and acid wastes to prevent pH changes that are harmful to aquatic life (Field, *et al.*, 1998). The natural buffering capacity of rivers varies with the character of the soil and bedrock in the various basins. Greater buffering capacity and increased alkalinity is usually observed in limestone-rich regions (Auer, *et al.*, 2014). Acidification, the addition of acids in river water, leads to the consumption of bicarbonate and carbonate which usually lessens the buffering capacity by reducing alkalinity and pH. Low alkalinity in river water can cause the change in the dynamics of chemical processes in the rivers (e.g., reduction in the frequency of calcium carbonate precipitation) impacting the well-being of aquatic creatures like fish and macroinvertebrates by mobilizing potentially toxic chemicals and reducing reproductive success (Wright *et al.*, 2007). For the reasons stated above, alkalinity of rivers is monitored in rivers around the world (Howland, *et al.*, 2000); (Ghosh, *et al.*, 2021); (Liu *et al.*, 2021).

Though a lot of work has done on monitoring physical and chemical properties of Turag like Conductivity, Total Dissolved Solids, Dissolved Oxygen, BOD and COD, alkalinity is not regularly measured (Islam and Azam, 2015); (Meghla *et al.*, 2013); (Mobin *et al.*, 2014). According to Wright *et al.*, 2011concrete infrastructures in urban areas on the bank of rivers are capable of providing additional weatherable material to an urban river water (Wright *et al.*, 2011). Experimental analysis of this article shows the presence of bicarbonate in high concentration due to the modification of rainwater through concrete pipes and down concrete gutters (Wright *et al.*, 2011). Agricultural contribution to increased alkalinity in surface waters can also result from similar processes, especially the addition of agricultural lime. Agricultural liming adds carbonate minerals to soils as a means of counteracting the acidifying effects of tilling, fertilizer usage, and nitrogen-fixing plants (Stets, *et al.*, 2014). As Turag is surrounded by both urban areas containing concrete infrastructures and agricultural lands, the measurement of alkalinity due to the addition of weathering materials is important. The present study is inspired by previous articles on alkalinity in urban rivers focuses on the seasonal variations of alkalinity in several important locations of Turag close to factories and agricultural land. The analysis of the alkalinity can give insight into the source of pollution in the river which could lead to effective remedies.

MATERIALS AND METHODS

Sample collection

11 locations along the Turag river were selected for sample collection with several point sources and non-point sources of pollution. Standard methods



Numbers	Name of the location
1	Amin bazar
2	Palpara Ghat
3	Kaundia Ghat
4	National zoo
5	Rupnagar pump house
6	Birulia Launch Ghat
7	Rustampur Gudara Ghat
8	Tongi
9	Abdullapur Kamarpara Bridge
10	Tongi Estema Ghat
11	Tongi Bazar Bridge

Fig. 1. The sampling points in the Turag river around Dhaka city. (Source: Modified from Google Maps, 2021) [Accessed 01 October 2021].

were followed to preserve samples for laboratory testing - surface water samples were collected from each site, stored in prewashed and dried polypropylene bottles and three drops of nitric acid (HNO_3, 70%, Sigma-Aldrich) was added to each sample and labeled (Eaton, *et al.*, 1995). Samples were taken from the Amin Bazar site to the Tongi Bazar Bridge site in September 2018 to represent the wet season and February 2019 to represent the dry season. Figure 1 shows all the 11 sampling locations.

Laboratory analysis

Total alkalinity was measured by standard titrimetric method as prescribed by APHA, AWWA (Eaton, *et al.*, 1995), where phenolphthalein indicator and methyl orange indicator were used for determining p-alkalinity due to carbonate and m-alkalinity due to bicarbonate. pH was measured on location using a pre-calibrated hand-held multimeter analyzer (HQ40d Multimeter, Hach, USA), for each sample, as per standard methods (Rice and Eaton, 2017)

RESULTS

The pH of the Turag river water was generally found to be slightly acidic to slightly alkaline as pH varies from 6.7-7.5 depending upon sample points (Figure 2) which predicts the presence of only bicarbonate and carbonate as OH- shows its presence only after a pH of 8.5 (Harris, 1998). Wet season pH was always higher in comparison with dry season for all sample locations indicating higher acidity in dry season.

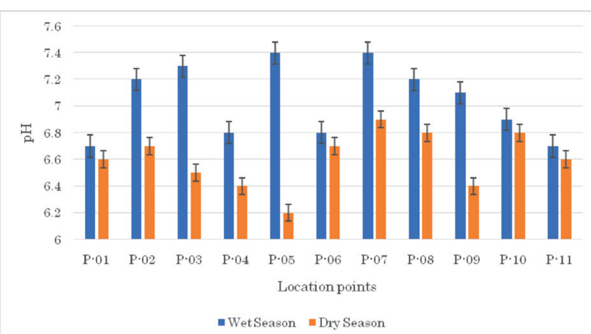


Fig. 2. Turag river water pH for dry and wet season

p-alkalinity due to carbonate was absent for all the samples as no samples showed color change due to the addition of phenolphthalein. So, m-alkalinity due to bicarbonate was calculated (Eaton *et al.*, 1995) by considering that total alkalinity for Turag mainly determinesalkalinity due to bicarbonate which is

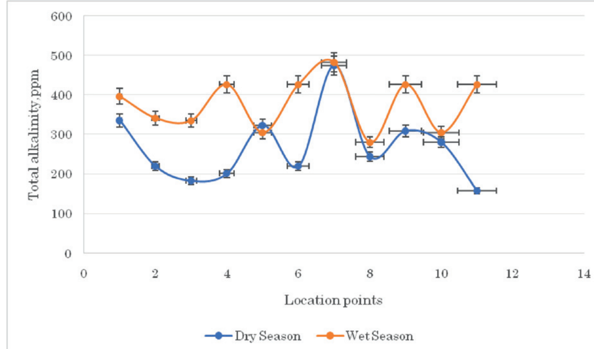


Fig. 3. Turag river water total alkalinity for bicarbonate (ppm)

acceptable regarding the range of pH observed during the study period.

From Figure 3, it can be clearly observed that for almost all the samples, Turag water alkalinity is higher in wet season. It suggests that though alkalinity is mainly dependent on the adjacent soil condition of rivers (Wright *et al.*, 2007), river water flow rate due to seasonal variations also influences the total alkalinity of Turag. Another key point which is visible from Figure 3, is that for both dry and wet season, Turag water alkalinity due to bicarbonate is far above the permissible range (25 to 400 ppm) (Khan, *et al.*, 2013). The alkalinity due to bicarbonate was above the limit in several locations (Figure 3).

DISCUSSION

Alkalinity due to bicarbonate salts in river water is thought to mainly come from weathering of carbonaceous rocks in the adjacent soil (Khan, *et al.*, 2013). In this study, the of bicarbonate concentration ranged from 158 to 483 ppm varying from dry to wet season accordingly (Figure 3). The lowest alkalinity of Turag throughout the entire study period was observed in Tongi Bazar Bridge location (P-11) in the dry season (158.8 ppm) which is within the permissible range for river water alkalinity (Khan, *et al.*, 2013). But wet season alkalinity in this point is quite high which can be explained from the location of bridge. There is a hospital near this sampling point. Hospital wastes contain plaster of Paris (gypsum plaster) from plaster casts and contains a lot of untreated bicarbonate (Navale, *et al.*, 2019) and this can be transferred through mixing with rainwater ultimately causing bicarbonate spike in the wet season (Figure 4).

The highest alkalinity was observed in

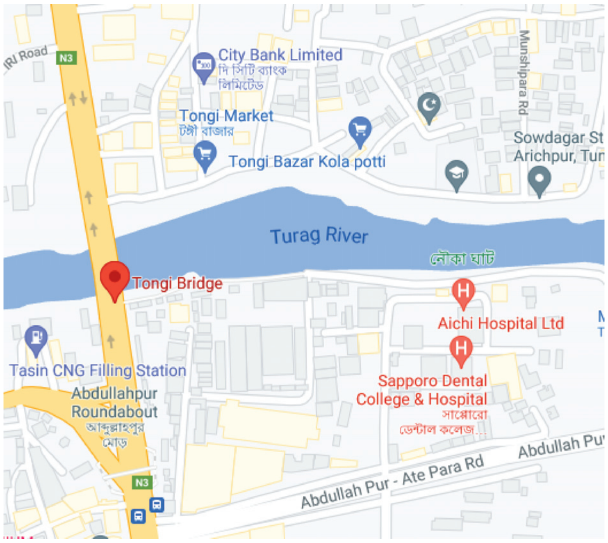


Fig. 4. Filling station, Hospital and Tongi Bridge near the sample location (Source: Modified from Google Maps, 2021) [Accessed 01 October 2021].

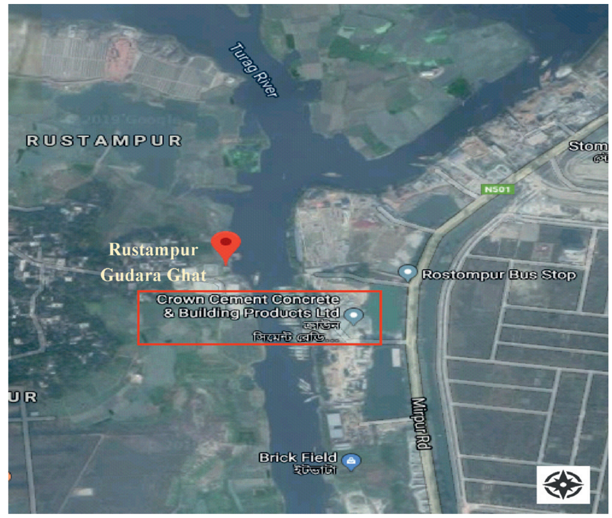


Fig. 5. The Cement plant near the site of sampling location. (Source: Modified from Google Maps, 2021) [Accessed 01 October 2021].

Rustampur Gudara Ghat (P-07) sample in dry and wet season because of probably the leaching of bicarbonate from the industries nearby this sample location. The point sources along this river include industries like leathers, textiles, metals processing, paper mills, electronic goods, power plant, fertilizers, pharmaceuticals, dyeing, battery manufacturing, ink manufacturing, metals melting. In addition, disposal of solid wastes, untreated sewage, terminal, and landing stations also contribute contaminant loads as point sources (Islam, *et al.*, 2015). A significant source of pollution during the dry and wet season may have been due to the cement plant situated at the bank of the river near the selected site as wastewater from cement industry contains a high concentration of pollutants like bicarbonates (Arimieari and Jaja, 2019).

Figure 5 shows the satellite image of the cement plant. Higher values of alkalinity during the wet season may be speculated due to higher flow of water in the river which caused mixing of bicarbonate from the cement industry (Wright *et al.*, 2011). On the other hand, during the dry season water flow decreases causing a slight decrease in alkalinity due to bicarbonate in this sample location.

The second highest alkalinity was found in several locations (P-04, P-06, P-11) in wet season (Figure 3) which was above the permissible range of alkalinity (Khan, *et al.*, 2020). Effluents from agricultural lands near the sites (Figure 6) and the proximity to the national zoo could be a possible source of high bicarbonate alkalinity as fertilizer runoff from agriculture and pesticides contain bicarbonate (Oh and Raymond, 2006). In case of Biruliya Launch Ghat (P-06), the possible source of high alkalinity is the concrete factory, which mainly releases a lot of bicarbonate through mixing with rainwater during wet season like the Rustampur Gudara Ghat (P-07) site mentioned above.

Alkalinity of river waters is an important parameter as they play a key role in chemical and biological processes in rivers (Wright *et al.*, 2007). It is clear from this analysis that any measurement of alkalinity in urban rivers like Turag needs to be carefully interpreted because of the presence of several different type of point sources along the river. The alkalinity levels at several places along the river are higher than the standard and regular monitoring of alkalinity may provide a proxy measure of pollution discharge into the river. This should help devise policy that targets a specific source (hospital, cement industry, agricultural runoff) rather than take a generalized approach of punishing all industries along the Turag. The high levels of alkalinity during the wet season is also a concern as it shows that the river is highly polluted even in high water flow situations, and efforts need to be taken to tackle this as soon as possible.

CONCLUSION

The results obtained shows that the level of alkalinity in an urban river, Turag is high at all times but due to the higher level of bicarbonate contamination from the discharge of untreated

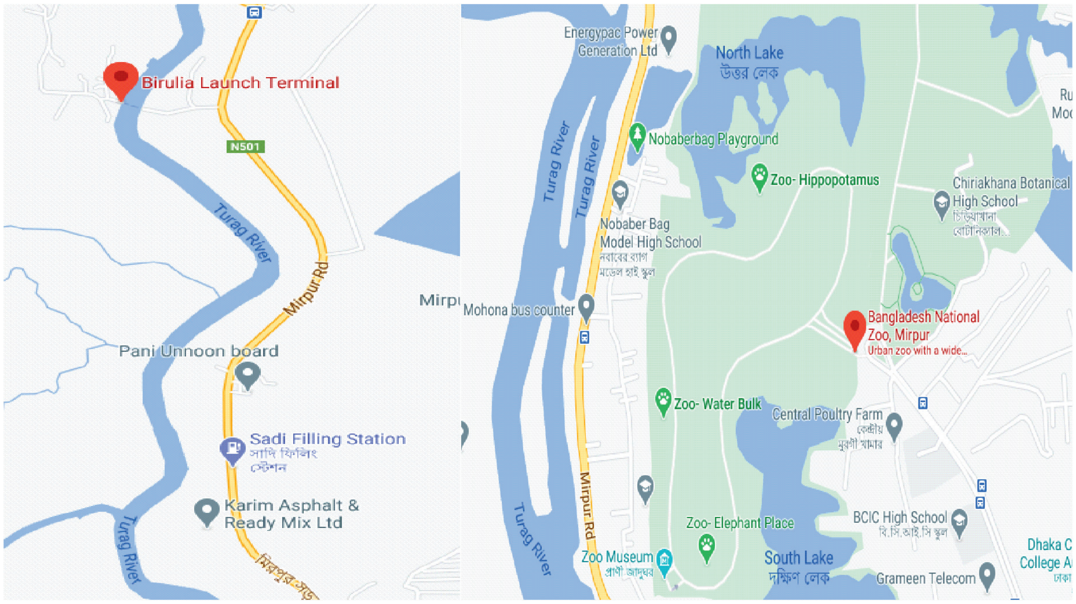


Fig. 6. Filling station, asphalt company and Cement industry near Biruliya Launch Ghat P-04 and Agricultural land near National Zoo P-06 (Source: Modified from Google Maps, 2021) [Accessed 01 October 2021].

wastewater from industries, alkalinity is higher in wet season compared to the dry season. There is no trace of carbonate in the water but on the other hand the level of bicarbonate is at a very high specially at locations near the concrete, cement factories and agricultural land. This echoes some of the findings from the work of Wright *et al.*, but their source of alkalinity was concrete pipes while in this study, whereas this study concludes that the source of pollution was the wastewater from specific industries along the river (Wright *et al.*, 2011). Careful consideration of the surrounding infrastructure and human activity along the banks of a river needs to be considered when analyzing for high levels of pollution as this study shows that industrial point sources of pollution have a huge effect on the alkalinity of the water.

REFERENCES

Islam, S. D.U. and Azam, G. 2015. Seasonal variation of physicochemical and toxic properties in three major rivers; Shitalakhya, Buriganga and Turag around Dhaka city. *Journal of Biodiversity and Environmental Sciences (JBES).* 7(3): 120-131.

Aktar, P. and Moonajilin, M.S. 2017. Assessment of Water Quality Status of Turag River Due to Industrial Effluent. *International Journal of Engineering and Information Systems (IJEAIS).* 1(6): 105-118.

Arimieari, L. and Jaja, G. 2019. Characteristics and Control of Effluents Generated From Industries in Port Harcourt, Nigeria. *American Journal of Engineering Research (AJER).* 8(2): 7-11.

Auer, M., Auer, N., Barkdoll, B. D., Bornhorst, T. J., Brook, C., Dempsey, D., and Watkins, D. 2014. The Great Lakes: Nutrients, sediments, persistent pollutants, and policy perspectives for a sustainable future. *Reference Module in Earth Systems and Environmental Science.* 4: 390-426.

Begum, T., Dey, S., Roy, K., Kamal, M., Khan, R. A. and Sultana, S. 2018. Assessment of Surface Water Quality of the Turag River in Bangladesh. *Research Journal of Chemistry and Environment.* 22(2): 49-56.

DoE. 2010. *Dhaka Environment and Water Project.* Dhaka: Department of Environment and Local Government Engineering Department.

Eaton, A. D., Clesceri, L. S., Greenberg, A. E. and Franson, M. 1995. *Standard Methods for the Examination of Water and Wastewater* (18th ed.). Washington, DC: American Public Health Association.

Field, C., Osborn, J., Hoffman, L., Polsenberg, J., Ackerly, D., Berry, J., and Mooney, H. 1998. Mangrove biodiversity and ecosystem function. *Global Ecology & Biogeography Letters.* 7(1): 3-14.

Ghosh, J., Chakraborty, K., Chanda, A., Akhand, A., Bhattacharya, T., Das, S., and Wells, M. 2021. Outwelling of total alkalinity and dissolved inorganic carbon from the Hooghly River to the adjacent coastal Bay of Bengal. *Environmental Monitoring and Assessment.* 193(7): 1-14.

Halder, J. N. and Islam, M. N. 2015. Water Pollution and its Impact on the Human. *Journal of Environment and Human.* 2(1): 36-46.

Harris, D. 1998. *Quantitative Chemical Analysis* (5th ed.).

New York: Macmillan.

Howland, R., Tappin, A., Uncles, R., Plummer, D. and Bloomer, N. 2000. Distributions and seasonal variability of pH and alkalinity in the Tweed Estuary, UK. *Science of The Total Environment.* 251-252: 125-138.

Ibanez, G. G., Hernandez-Esparza, M., Doria-Serrano, C., Fregoso-Infante, A. and Singh, M. M. 2008. *Alkalinity and Buffering Capacity of Water* (1st ed.). New York: Springer.

Islam, M. S., Uddin, M. K., Tareq, S. M., Shammi, M., Kamal, A. K., Sugano , T. and Kuramitz , H. 2015. Alteration of Water Pollution Level with the Seasonal Changes in Mean Daily Discharge in Three Main Rivers around Dhaka City, Bangladesh. *Environments.* 2(3): 280-294.

Khan, N., Hussain, S. T., Saboor, A., Jamila, N. and Kim, K. S. 2013. Physicochemical investigation of the drinking water sources from Mardan, Khyber Pakhtunkhwa, Pakistan. *International Journal of Physical Sciences.* 8(33): 1661-1671.

Khan, S. A., Ahammed, S. S., Rabbani, K. A. and Khaleque, M. A. 2020. Water Quality Assessment of Turag River Using Selected Parameters. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT).* 14(1): 61-66.

Khan, S. A., Karobi, S. N., Ahammed, S. S., Rabbani, K. A. and Islam, M. E. 2020. Assessment of selected water quality parameters of Turag River in Dhaka, Bangladesh. *Pollution Research.* 39 (November Suppl. Issue). 39-42.

Liu, Y., Wang, Y., Xu, S., Hu, W. and Wu, Y. 2021. Design and Implementation of Online Monitoring System for Soil Salinity and Alkalinity in Yangtze River Delta Tideland. *IEEE International Conference on Artificial Intelligence and Industrial Design (AIID).* 521-526.

Meghla, N., Islam, M., Ali, M., Suravi and Nargis, S. 2013. Assessment of physicochemical properties of water from the Turag River in Dhaka City, Bangladesh. *International Journal of Current Microbiology and Applied Sciences.* 2(5): 110-122.

Mobin, M., Islam, M., Mia, M. and Bakali, B. 2014. Analysis of physicochemical properties of the Turag River water, Tongi, Gazipur in Bangladesh. *Journal of Environmental Science and Natural Resources.* 7(1): 27-33.

Navale, G., Gohil, K., Puppala, K., Shinde, S. S., Umbarkar , S. and Dharne, M. 2019. Rapid and greener method for utilization of Plaster of Paris (POP) waste generated from biomedical samples. *International Journal of Environmental Science and Technology.* 16(5): 2475-2480.

Oh, N.-H. and Raymond, P. A. 2006. Contribution of agricultural liming to riverine bicarbonate export and CO2 sequestration in the Ohio River basin. *Global Biogeochemical Cycles.* 20(3).

Pakulski, I., Laroche, V., Kazi, S., Shawky, A., Khaleduzzaman, A., Urrutia, I.and Engle, N. 2021. *The Bangladesh Delta : A Lighthouse Case Study.* Washington, DC.: World Bank.

Rice , E., R.B., B. and Eaton, A. 2017. *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). American Public Health Association.

Stets, E. G., Kelly, V. and Crawford, C. 2014. Long-term trends in alkalinity in large rivers of the conterminous US in relation to acidification, agriculture, and hydrologic modification. *Science of the Total Environment.* 488: 280-289.

Wright, I., Davies, P., Findlay, S. and Jonasson, O. 2011. A new type of water pollution: concrete drainage infrastructure and geochemical contamination of urban waters. *Marine and Freshwater Research.* 62(12): 1355-1361.

Wright, I. A., Davies, P., Findlay, S. and Taylor, M. P. 2007. Aquatic macroinvertebrates in urban waterways: comparing ecosystem health in natural reference and urban streams. *Proceedings of the 5th Australian Stream Management Conference. Australian rivers: making a difference*. 467-472.