Trends in Undergraduate Research (2025) 8(2): a8-16
https://doi.org/10.33736/tur.9658.2025

Analysis of Stomach Content from Estuarine Crocodiles in Sarawak

Ruhana binti Hassan[a,*], Mohd Izwan Zulaini bin Abdul Gani[b] and Mohamad Zahin Hazwan bin Hamedi[a]
[a]*Faculty of Resource Science and Technology,Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia*
[b]*Sarawak Forestry Corporation, Lot 218, KCLD, Jalan Sungai Tapang, Kota Sentosa, 93250 Kuching, Sarawak, Malaysia*

Received 9 May 2025, Revised 5 Disember 2025, Accepted 6 Disember 2025, Published 14 December 2025
*Corresponding author's email: hruhana@unimas.my

Abstract

The population of Estuarine crocodiles (Crocodylus porosus) in Sarawak has increased over the past three decades. This population increase is believed to be associated with the rising number of crocodile attacks on human and livestock. However, the ecological factors underlying human-crocodile conflicts (HCC) remain poorly understood. Studying the gut contents of C. porosus is essential to understand their feeding behaviour and ecological role, providing insights that could help mitigate this long-standing HCC. Therefore, this study is carried out to assess the type and the amount of non-organic and organic items found in the crocodile stomach. Five individuals of adult crocodiles were examined for stomach contents following the standard operating procedure. The analysis revealed a total of 44 pieces of non-organic items are found in the crocodile stomachs, with plastic debris is the most common, followed by metal, fabric and glass. The organic items mainly consist of skeletal remains such as skull, bones, and other remnants of prey items. The findings of this study established baseline data on stomach content of adult crocodiles in Sarawak. The heterogenous composition of ingested materials indicates a high degree of complexity in the species' feeding behaviour. In future, more in-depth research questions should be emphasized especially pertaining to feeding activity and pattern which will be useful for sustainable management of the HCC.

Keywords: *Estuarine crocodiles, Stomach content, Plastics*

1. INTRODUCTION

Estuarine crocodiles or saltwater crocodiles, *Crocodylus porosus* is commonly found in Sarawak (Hassan and Gani, 2013). The mean size at which males mature has been estimated to be 160 cm SVL (snout-vent length), whereas the mean size at which females mature has been determined to be 110 cm SVL (Webb et al., 1978). This species of crocodile has been assessed with the least concern assessment in the IUCN Redlist by the International Union for Conservation of Nature (IUCN) in the wild. Moreover, Malaysian population of *C. porosus* was moved to CITES Appendix II in 2016 which encourage the State of Sarawak to execute a wild harvest and ranching programme to manage rising levels of Human-Crocodile Conflict (HCC). This crocodile species also has an extensive distribution, ranging from southern India and Sri Lanka, through southeast Asia, the Philippines, Micronesia, Indonesia, Papua New Guinea, and the Solomon Islands, to northern Australia (Webb et al., 2010). As a keystone species, apex predators, indices of ecological health, and agents of nutrient and energy transfer between different ecosystems, estuarine crocodiles play a critical role in ecosystem dynamics

and maintain ecological balance (Somaweera et al., 2020). Understanding their dietary habits, including the consumption of non-organic items, is crucial for effective conservation and management efforts. Marine species regularly come into contact with plastics and either consume it or become entangled in it (Kühn & van Franeker, 2020). Consumption of marine debris can be observed through estuarine crocodiles as their habitat is commonplace to suffer solid waste pollution, for example from garbage dumping by nearby local residents. Adult crocodiles may also be spotted close to settlements, most likely because food was accessible there since household waste was often dumped into rivers (Hassan et al., 2018). Lading and Das (2021) carried out research on the intake of organic materials by young estuarine crocodiles. Concerns are raised regarding the possible ecological effects and health dangers connected with ingesting these non-organic materials, such as plastic trash, fishing gear, and other man-made objects. Crocodiles are capable of ingesting significant amounts of microplastics throughout the course of their lifetimes, either mistakenly absorbing plastic components or digesting microplastic particles that have accumulated within their food (Gonzalez-Jauregui et al., 2019). This implies that the bigger the size the more likely crocodiles are to have plastics or inorganic item inside their stomach.

Non-organic material refers to any item that could not be eliminated by microbial or chemical breakdown (Stephens and Calder, 2004). Non-organic item includes plastics, styrofoam, rubber, etc. Marine debris (also known as marine litter), which is defined as solid produced or processed waste that enters the marine environment, is a remarkably overlooked source of marine pollution (Hofer, 2008). The ocean, which collects a variety of trash known as marine litter, may be the world's largest landfill (Schneider et al., 2018). Metals, glass, pottery, textiles, paper, and wood all fall under marine litter. Plastic trash, however, according to Jambeck et al. (2015) makes up the majority of marine litter and is likely the most harmful. Approximately 12.7 million tonnes of plastic trash are thought to enter the ocean annually from only land-based sources .

In Malaysia, Sarawak is home to the majority of crocodiles (Gani et al., 2022). Crocodiles have long lived in Sarawak waterways, as evidenced by the presence of "Baya Tanah," effigies of crocodiles that can be seen in a number of places around the state, notably in Engkilili, Kanowit, and Kapit (Gani et al., 2022). Human-crocodile conflict (HCC) is no strangers to residents of this state. According to Gani et al., (2022) the pattern of human activity in Sarawak is related to that of crocodile attacks. Culling of crocodiles have been made by the Sarawak Forestry Corporation in respond to HCC.

However, up to December 2024, there has been no publication on type and abundance of non-organic item found in estuarine crocodiles. Therefore, objective of this study is to determine the type and the abundance of non-organic items found in stomach of estuarine crocodiles caught in rivers in Sarawak.

2. MATERIALS AND METHODS

This study included 5 river system in Sarawak, namely (i) Sg. Sarawak at Satok Bridge; (ii) Sg. Tabuan at Kg. Tabuan Hilir; (iii) Sg. Sibu Laut at Kg. Telaga Air , (iv) Btg Salak at Kuching Wetland RAMSAR Site and (v) Sg. Padeh, Btg Saribas, Betong, central Sarawak. In collaboration with the Sarawak Forestry Corporation (SFC), the crocodile gut contents were obtained from their facility on the 30th of March 2023. The cause of the death of all crocodiles are uncertain, while sample number 3 was from exercise of culling in Sungai Sibu as a response to human-crocodile conflict (HCC).

The stomachs were thawed and washed using tap water through a 2 mm polyvinyl chloride (PVC) net. All non-organic items were washed again and dried under the sun. The non-organic items were classified into 4 categories namely plastic, fabric, metal, and glass (Ribic et. al.,1992). Plastics were classified into two sub-categories; (i) mesoplastics which is from5 mm to2.5 cm in size, and (ii) macroplastics which is more than 2.5 cm (Cheshire et al., 2009) and Blettler et al. (2017). Naked eye inspection of the contents of the stomach was implemented (Cliff et al., 2002) followed by sorting the gut content. The non-organic items sorted were weighed using a digital balance (Tanita KD-200) (up to 0.1 gram) as well as counted manually. Pictures of non-organic samples obtained from the stomach of crocodiles was also be taken to provide a clear depiction of the samples procured. In addition, pictures of bones, skulls, and others were photographed using a smartphone for record. Number of item and weight were recorded and analyzed using descriptive analysis.

3. RESULTS AND DISCUSSION

3.1 Results

This study involved 5 adult crocodiles comprised 3 males and 2 females (Table 1). All crocodiles were found as carcasses except for individual number 3.

Table 1. Sample of the study

Individual	Gender	Total Length (m)	Location and condition
1	Male	4.43	Sg. Sarawak at Satok Bridge; near residential area
2	Female	2.67	Sg. Tabuan at Kg. Tabuan Hilir, near residential area
3	Male	3.65	Sg Sibu Laut, Kg Telaga Air; crocodile was trapped near a seafood restaurant, culling exercise due to human-crocodile conflict in the area
4	Female	2.44	Btg Salak at Kuching Wetland RAMSAR Site
5	Male	2.48	Sg. Padeh, Btg Saribas, Betong, central Sarawak, near residential area

Debris of plastics were found in all 5 crocodiles whereas metal was found in two of the crocodiles (Table 2). The total number of plastics (meso- and macro-) found were 39 pieces. Individual number 3 had consumed the largest number of plastics (n= 26) whereas individual number 4 and 5 were found to have the least number of plastics in their stomach. Only one metal was found which is in individual number 1 (bundle of wires) and one nail was found in individual number 4. Two pieces of fabrics were found in the stomach of individual number 1. One piece of glass sharp was found in individual number 5.

Table 2: Non-organic items found in the gut of crocodiles

Individual	Plastic (meso)	Plastics (macro)	Metal	Glass	Fabric
1	0	7	1	0	2
2	2	2	0	0	0
3	1	25	0	0	0
4	1	0	1	0	0
5	1	0	0	1	0
TOTAL	5	34	2	1	2

The weight of plastic items found in 5 crocodiles were 489.7 g which is the highest out of the four categories, 37.5 g for metals, 36.2 g for fabrics, and 0.4 g for glasses (Figure 1). The total weight of all non-organic items found in all 5 crocodile stomachs is 563.8 g. Individual 3 consumed the most plastics by weight (238.6 g), whereas individual 5 consumed the least plastics by weight (0.1 g). Other than that, individual 4 consumed the most metal by weight (26.4 g) compared to individual 1 (11.1 g). Figure 2 describes number of plastic debris in each crocodile. Individual 3 has the highest number of plastic items consumed (n=26), while individual 1 has the second highest number of plastic items consumed (n= 7). Both individual number 3 and 1 were male crocodiles. Individual number 5 is also a male but smaller in size (TL=2.84m). Individual 1 has the largest size (TL= 4.43 m) while individual 3 has the second largest size recorded (TL= 3.65 m). As all crocodiles had plastics in the stomach, Figure 2 shows that the highest number of plastics was found in an adult male.

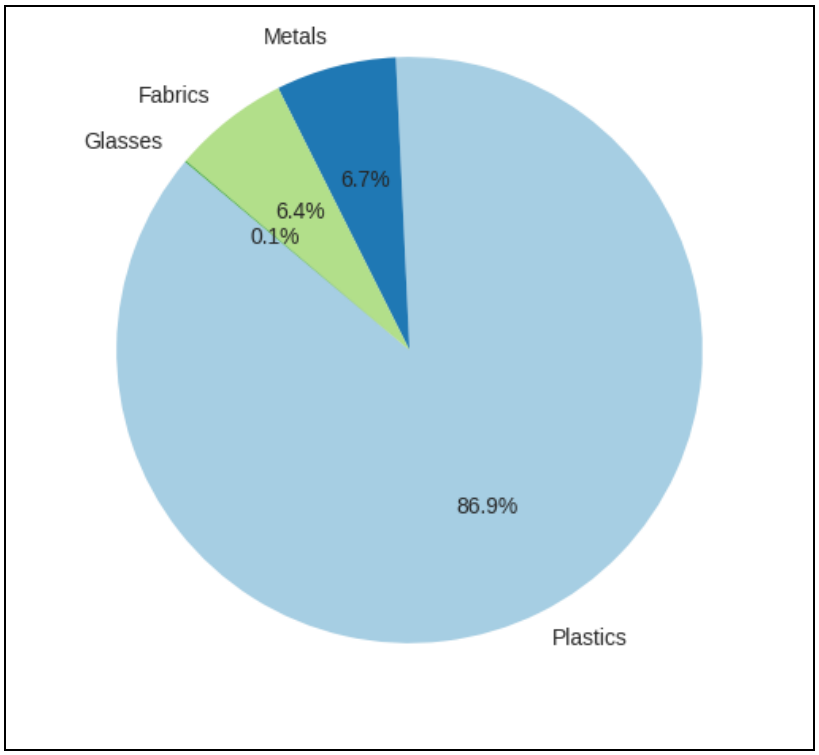

Figure 1: Distribution (in percentage) according to categories (plastics, glasses, fabrics and metals) found in the stomach of five adult crocodiles.

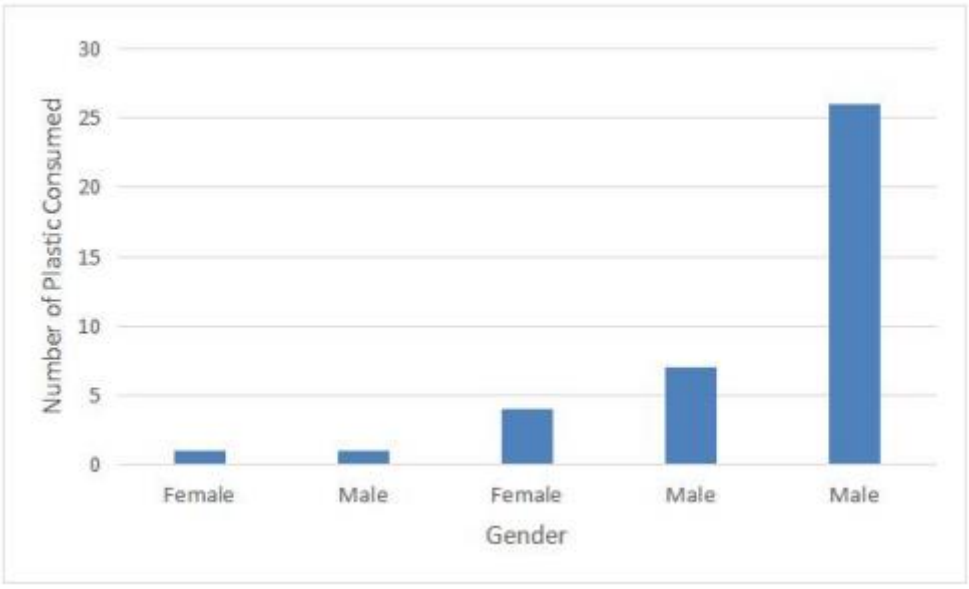

Figure 2: Number of plastic debris in each crocodile.

In this study, only four stomachs contained skull, bones, and other organic items. The bones that are attached were counted as one. Individual number 1 had a monitor lizard (TL~1m) in its stomach (Figure 3). Individual number 4 was found to have a carcass of a horseshoe crab (Figure 4) that was in a crushed state, including a piece of bone inside its stomach. Approximately 10 pieces of bones and 22 pieces of claw-bones were found inside individual number 5 (Figure 5).

Figure 3**.** Individual number 1 had a monitor lizard *Varanus salvator* (TL ~ 1m) in its stomach.

Figure 4. Individual number 4 had a carcass of a horseshoe crab *Carcinorcorpius rotundicauda* in its stomach.

Figure 5. Approximately 10 pieces of bones and 22 pieces of claw-bones were found inside individual number 5, most likely belonging to small Primates and Order Rodentia (rats, squirrels).

3.2 Discussion

The samples in this study (n =5, mean TL 3.21 m) were considered as adult crocodiles (Webb et al., 2010).Plastic items were found to be the most abundant type of non-organic item consumed by crocodiles, where macroplastics were found to be more than mesoplastics. In contrast, Lading and Das (2021) reported that juvenile's gut did not contain any piece of marine litter or non-organic item. It is possible that while crocodiles attack the preys, they accidently swallow the plastics. Between 60 and 80% of the world's marine garbage is made of plastic components (Derraik, 2002). A key source of ocean plastics is rivers that carry waste through communities before dumping it at sea (Lebreton et al., 2012, Cózar et al., 2015). Individual number 3 was found to have the highest amount of plastic in its stomach (n=26). This crocodile had eaten one big plastic bag which contained many pieces of smaller size plastics of various kinds.

It was a challenge in determining the weight of items found in the stomach of crocodiles because of a layer of oil coating present on almost all gut contents. On the other hand, the metal that was found in individual number 1 (11.1 g) was a bundle of wires that clumped up together. The metal that was found in individual number 4 (26.4 g) was a piece of a large broken nail, this explains the difference in weight although each of the crocodile scored one item of metal in the stomach. The weight of plastics can also show the differences in these two types of data. For example, although the amount of plastic found were 7 and 26 in individual number 1 and 3, respectively; the weight recorded were 224.3 g and 238.6 g. Therefore, one may say the weight is not reliable metric for estimating the feeding behaviour. In this study, the non-organic item comprised drinking straws, plastic bags, plastic ropes, food packages, water bottles, and such which most are daily necessities (Awasthi et al., 2017). A few pieces of debris from fish nets were also found inside the stomach of the crocodiles.

The highest amount of plastic consumed was by individual number 3 (26 pieces) followed by individual number 1 (7 pieces) where the size of the crocodile were 3.65 m and 4.43 m, and both were male crocodiles. In general, larger size crocodiles tend to have a higher chance of consuming trash.

Many animals mistook garbage for food, and once they have ingested anything, they are unable to vomit it (Sheavly and Register, 2007). Hassan et al. (2018) also reported that large crocodiles were found near human settlements, where they were found to be foraging in leftover rubbish.

The mean values that were calculated in this study are not able to determine any significance such as the mean for non-organic item consumed (8.8) and the mean size of crocodiles (3.21m) as the sample size utilized in this study is too small. Due to the small number of samples used, there is also no evidence that gender and size influence the amount of plastic consumed by crocodiles. In addition, *C. porosus* are considered to be opportunistic feeders (Caldicott et al., 2005; Erickson et al., 2012), but limited knowledge was published on their nocturnal hunting tendencies (Evans et al., 2017). Many cryptic species, like crocodilians, have complicated behaviors that are not well understood, and little is known about their wild hunting behavior.

The importance of knowing the location could help in identifying the possible reason for non-organic item consumption by the crocodiles. Individual number 3 which is the crocodile with the highest non-organic item consumption was obtained in an area perpendicular to restaurants in Sungai Sibu, Sarawak. In an area where human settlements are present, trash and garbage alike are common and often end up in rivers. According to several studies, both home and non-domestic waste contaminated the majority of urban drainage systems (Olabode and Lawrence, 2014; Oktiawan and Amalia, 2012). Similarly, individual number 1 and 2 were also obtained near residential areas which may explain the presence of non-organic items in their digestive systems. However, individual number 4 was found dead in an area inside the Kuching Wetlands which is a National Park, an area that is protected from harmful human activities. It is possible that this individual consumed garbage from outside Kuching Wetlands area as their nature of roaming the waterways for food and mating. Female crocodiles stay in a region of the river less than one kilometer long for breeding, but they moved up to 54 km in distance from the breeding area to build their nests (Campbell et al., 2013). During the mating and nesting season, male *C. porosus* may migrate at high rates (6.49±0.9 km per day) (Campbell et al., 2013). Since many crocodile habitats are located near fishing communities and tourist areas, motorboat traffic, oil, noise, rubbish, polythene, and used fishing nets and equipment may have an adverse effect on the animals living there (Amarasinghe et al., 2015).

Sarawak rivers are known for its abundance in natural resources, especially food sources such as fish and aquatic vegetation. However, crocodiles are also drawn to garbage dumps by the stench of trash or by the smell of other prey animals like rats, birds, and dogs, who are drawn to food that has been placed there. Approximately 28 prey items that was found inside the crocodile stomachs indicated that they had been feeding on reptiles (monitor lizards), small mammals (rodents), and even crustacean (horseshoe crab). According to Lading and Das (2021), these are the common food items for *C. porosus* in Sarawak. The claws that were obtained from individual number 5 are highly suspected to originated from a reptile, probably monitor lizard, similar to those found in individual number 1. The diversity of prey items found in 4 out of the 5 crocodiles indicated that estuarine crocodiles are opportunistic feeders which are able to adapt to whatever food is available at the habitat.

4. CONCLUSIONS AND RECOMMENDATIONS

A total of 44 pieces of non-organic items were found in the crocodile stomachs including plastics, fabrics, metals, and glass whereby the plastic debris were the most common item that was found. Due to limited number of samples involved in this study, there is no clear evidence whether the size and gender influence the abundance and types of trash consumed by crocodiles in Sarawak. This study also recorded that 80% of the samples contained organic remains which include skulls, bones, and other remnants of prey items which shows the diverse diet of crocodiles. The data from this study could be used as a baseline for future research on crocodiles in Sarawak. A small number of samples were involved in this study, therefore, more samples representing different cohorts (size) should be used in future studies.

ACKNOWLEDGEMENTS

Authors would like to thank Sarawak Forestry Corporation for: (i) approving application permit This study has a permit approval from Sarawak Forestry Corporation SFC810-4/6/19(2023)-063.in the Sarawak Online Research Application System (SORAS) (ii) providing samples of guts which were kept in SFC facilities. Thank you to Universiti Malaysia Sarawak for land transportation and laboratories and other research facilities.

CONFLICT OF INTEREST

We declare no conflict regarding the publication of the study

REFERENCES

Abdul Gani, M.I.Z., Hassan, R, Tisen, O.B. & Ahmad R., (2022). Human-Crocodile Conflicts in Sarawak Malaysian Borneo: An Analysis of crocodile attacks from 2000 to 2020. *International Journal of Biology and Biomedical Engineering*, 16, 186-195. DOI: 10.46300/91011.2022.16.25

Amarasinghe, A.A.T., M.B. Madawala, D.M.S.S. Karunarathna, S.C. Manolis, A. deSilva & R. Sommerlad (2015). Human-crocodile conflict and conservationimplications of Saltwater Crocodiles *Crocodylus porosus* (Reptilia: Crocodylia: Crocodylidae) in Sri Lanka. *Journal of Threatened Taxa*, 7(5), 7111–7130. DOI:10.11609/JoTT.o4159.7111-30

Awasthi, A.K., Shivashankar, M. & Majumder, S. (2017). Plastic solid waste utilization technologies: A Review. *IOP Conf. Series: Materials Science and Engineering*, 263, 022024. DOI:10.1088/1757-899x/263/2/022024.

Blettler, M.C.M., Ulla, M.A., Rabuffetti, A.P. & Garello, N. (2017). Plastic pollution in freshwater ecosystems: macro-, meso-, and microplastic debris in a floodplain lake. *Environmental Monitoring and Assessment*, 189(11). DOI:10.1007/s10661-017-6305-8.

Caldicott, D.G.E., Croser, D., Manolis, C., Grahame & Britton, A. (2005). Crocodile Attack in Australia: An Analysis of Its Incidence and Review of the Pathology and Management of Crocodilian Attacks in General. *Wilderness &Environmental Medicine*, 16(3), 143–159. https://doi.org/10.1580/1080-6032(2005)16[143:CAIAAA]2.0.CO;2

Campbell, H.A., Dwyer, R.G., Irwin, T.R. & Franklin, C.E. (2013). Home Range Utilisation and Long-Range Movement of Estuarine Crocodiles during the Breeding and Nesting Season. *PLoS ONE* 8(5), e62127. DOI:10.1371/journal.pone.0062127.

Cheshire, A.C., Adler, E., Barbière, J., Cohen, Y., Evans, S., Jarayabhand, S., Jeftic, L., Jung, R.T., Kinsey, S., Kusui, E.T., Lavine, I., Manyara, P., Oosterbaan, L., Pereira, M.A., Sheavly, S., Tkalin, A., Varadarajan, S., Wenneker, B. & Westphalen, G. (2009). UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter. UNEP Regional Seas Reports and Studies, No. 186; IOC Technical Series No. 83. DOI:10.25607/OBP-726.

Cliff, G., Dudley, S. F. J., Ryan, P. G., & Singleton, N. (2002). Large sharks and plastic debris in KwaZulu-Natal, South Africa. *Marine and Freshwater Research*, 53(2), 575–581. DOI:10.1071/MF01146

Cózar, A., Sanz-Martín, M., Martí, E., J.I. González-Gordillo, Bárbara Úbeda, Gálvez, J.A., Xabier Irigoien & Duarte, C.M. (2015). Plastic Accumulation in the Mediterranean Sea. *PLoS ONE*, 10(4), e0121762. DOI:10.1371/journal.pone.0121762.

Derraik, J.G.B., (2002). The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin*, 44(9), 842–852. DOI:10.1016/S0025-326X(02) 00220-5.

Erickson, G.F., Gignac, P.M., Steppan, S.J., A. Kristopher Lappin, Vliet, K.A., Brueggen, J., Inouye, B.D., Kledzik, D. & Grahame (2012). Insights into the Ecology and Evolutionary Success of Crocodilians Revealed through Bite-Force and Tooth-Pressure Experimentation. *PLoS ONE*, 7(3), e31781. DOI:10.1371/journal.pone.0031781.

Evans, L.M., Davies, A., Goossens, B. & Asner, G.P. (2017). Riparian vegetationstructure and the hunting behavior of adult estuarine crocodiles. *PLoS ONE*, 12(10), e0184804. DOI:10.1371/journal.pone.0184804

Gonzalez-Jauregui, M., Borges-Ramirez, M., Barão-Nóbrega, J.A.L., Escamilla, A., Dzul-Caamal, R. & Rendón-von Osten, J. (2019). Stomach flushing technique applied to quantify microplastics in Crocodilians. *Methods X*, 6, 2677–2685. DOI:10.1016/j.mex.2019.11.013.

Hassan, R., & Abdul-Gani, M. I. Z. (2013). Crocodiles in Western of Sarawak, Malaysia. Pp 90-94. In World Crocodile Conference. Proceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. Gland, Switzerland: IUCN.

Hassan, R., Md Adzhar, M. A. A., Abdul-Gani, M. I. Z., & Ahmad, R. (2018). Assessment of Wild Saltwater Crocodile Population in Bako River, Western Sarawak, Malaysian Borneo for Potential Ecotourism Industry. *Malaysian Applied Biology*, 47(1), 131-138.

Hofer, T. N. (2008). *Marine pollution: New research*. Nova SciencePublishers, NewYork.

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R. & Law, K.L. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768–771. DOI:10.1126/science.1260352.

Kühn, S., & van Franeker, J. A. (2020). Quantitative overview of marine debris ingested by marine megafauna. *Marine Pollution Bulletin*, 151, 110858. DOI:10.1016/j.marpolbul.2019.110858.

Lading, E., & Das, I. (2021). Diet of Juvenile *Crocodylus porosus* at Kuching Wetlands National Park, Sarawak, East Malaysia. *Asian Herpetological Research*, 12(3), 323–330. DOI:10.16373/j.cnki.ahr.200107

Lebreton, L., Greer, Sd. & Borrero, J.C. (2012). Numerical modelling of floatingdebrisin the world's oceans. *Marine Pollution Bulletin*, 64(3), 653–661. DOI:10.1016/j.marpolbul.2011.10.027.

Oktiawan, W., & Amalia, S., 2012. Pengaruh Kondisi Sistem Drainase, Persampahan dan Air Limbah Terhadap Kualitas Lingkungan (Studi kasus Kelurahan KuninganKecamatan Semarang Utara). Jurnal Presipitasi: *Media Komunikasi dan Pengembangan Teknik Lingkungan*, 9(1), 41-50. DOI:10.14710/presipitasi.v9i1.41-50.

Olabode, A.D. & Lawrence, A. (2014). Environmental Impact of Indiscriminate WasteDisposal on River Channel in Part of Akoko-region, Ondo State, Nigeria. *International Journal of Innovation and Scientific Research*, 5, 162-168. Available from: https://www.researchgate.net/publication/308079417

Ribic, C. A., Dixon, T. R., & Vining, I. (1992). Marine Debris Survey Manual. Washington, DC, NOAA Techincal Report NMFS, 108, 94.

Schneider, F., Parsons, S., Clift, S., Stolte, A. & McManus, M.C. (2018). Collected marine litter — A growing waste challenge. *Marine Pollution Bulletin*, 128, 162–174. DOI:10.1016/j.marpolbul.2018.01.011.

Sheavly, S.B. & Register, K.M. (2007). Marine Debris & Plastics: Environmental Concerns, Sources, Impacts and Solutions. *Journal of Polymers and the Environment*, 15, 301–305. DOI:10.1007/s10924-007-0074-3.

Somaweera, R., Nifong, J.C., Rosenblatt, A., Brien, M.L., Combrink, X., Elsey, R.M., Grigg, G.C., Magnusson, W.E., Mazzotti, F.J., Pearcy, A., Platt, S.G., Shirley, M.H., Tellez, M., Douwe, J., Grahame, Whitaker, R. & Webber, B.L. (2020). The ecological importance of crocodilians: towards evidence-based justification for their conservation. *Biol. Rev. Camb. Philos. Soc.* 95(4), pp.936–959. DOI:10.1111/brv.12594.

Stephens, W.E. & Calder, A. (2004). Analysis of non-organic elements in plant foliage using polarised X-ray fluorescence spectrometry. *Analytica Chimica Acta*, 527(1), 89–96. DOI:10.1016/j.aca.2004.08.015.

Webb, G., Manolis, S.C. & Brien, M.L. (2010). Saltwater Crocodile *Crocodylus porosus*. Pp. 99-113 in Crocodiles. Status Survey and Conservation Action Plan. Third Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin.Australia

Webb, G., Messel, H., Crawford, J. & Yerbury, M. (1978). Growth Rates of *Crocodylus porosus* (Reptilia: Crocodilia) From Arnhem Land, Northern Australia. *Wildlife Research*, 5(3), 385. DOI:10.1071/wr9780385.