

An analysis of River Derwent pollution and its impacts

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Abstract: As the major water catchment in Hobart city, the River Derwent provides water services to Hobart residents; however, water quality of the River Derwent is becoming unreliable. The aims of this paper are to identify the major water issues in the river and to reveal its impacts on Hobart residents and ecosystem. A methodology of secondary data analysis has been involved; which covers a wide range of existing dissertations. Through all the analysis of data, heavy metals, contaminated sediment and overload nitrogen can be regarded as three main causes of the water pollution. Moreover, the impacts of the water pollution are proved to be significant and perennial. On the basis of the analysis result, water pollution tends to be a tough issue that requires a great amount of time and efforts to deal with.

Keywords: Water pollution; Heavy metal contamination; Contaminated sediment

Introduction

Hobart, the capital city of Tasmania, sits along the Derwent Estuary, surrounded by tree-covered hills. Blessed with such a unique location, Hobart appears to have the advantage of processing many quality resources of its natural assets. As the most critical nature asset, the River Derwent is irreplaceable because approximately 40% of Tasmania's population (around 202 000 people) lives around the estuary (Hobart City Council, 2009). It also acts as the breeding grounds for fishes, resting areas for migratory birds and provides recreational activities. Apart from these functions and uses, the river supports various industries including paper production, zinc melting, shipbuilding and hydroelectric power. In terms of its natural conditions, the annual surface water temperature varies from 8-22 degrees and its salinity ranges from 11-15 ppt up to 35 ppt depending on different river flows and tidal influence (Whitehead J *et al.* 2010). This kind of moderate environment is suitable for marine species to either quickly colonize or to tolerate fluctuation in water temperature and salinity. Over last decades, the River Derwent was noted for its

attractive natural scenery.

Nevertheless, the river has numerous discharges; including wastewater treatment plants outfalls, storm-water and natural rivers' input. As a result, contaminants could enter the river from diverse sources: potentially toxic heavy metals from mineral processing and manufacturing. The water pollution in River Derwent thus becomes a prime environmental issue. The purpose of this paper is to present the current pollution status of this river and its impacts. Therefore, this paper will firstly review the current management on this river and then analysis its main contaminants as well as its wider impacts.

1 Existing documents focusing on protecting the river

In order to improve its water quality, Hobart City Council (HCC) in cooperation with other agencies developed numbers of projects and carried out various documentations. For instance: projects including the Derwent Estuary Program (DEP), Catchment Management Plans (CMPs) and so on; documentations including Water Sensitive Urban Design Guidelines (2006), Soil and Water Management on Building and Construction Sites

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(2008), Public Environmental Report and River Derwent Catchment Flood Management Plan.

Among these projects, DEP is of great importance due to its constructive improvements and protections to the river. In 1999, DEP was firstly established as an initiative of local Government to restore and protect the Derwent Estuary. DEP guides various activities to enhance the estuary's values as well as to encourage community involvement. Although great efforts have been made for more than a decade, the Derwent remains a significantly degraded estuary.

2 Main contamination indicators

The River Derwent is highly impacted by several major industrial and urban contaminated sources throughout its catchments. According to DEP's annual report (2012), the major contaminated sources include plant outfalls, con-

taminated storm water, boat wastes and aquacultures. Among these sources, heavy metals contaminants in particular, represent the most fatal threat. In past decades, progressive projects have been carried out to deal with the contamination issues. A set of data shows a substantial reduction (around 60%) on the source of heavy metals over the last decade (Heavy Metals Project, 2015). Nevertheless, a great deal of heavy metals has been accumulated in its sediment over a period of 60-70 years and release slowly. Thus, the level of heavy metal in the river is still at a high level; in particular, levels of zinc, mercury, cadmium and lead are above International Sediment Quality Guidelines (ISQG). A recent study into heavy metals components in the river presented a clear vision of the current dangerous levels. The results of heavy metal analyses are shown in Table 1.

Table 1 Result in mg/kg DMB of sediments heavy metal analyses (Source: Aquatic Science, 2007)

Analyses	Study 1	Study 2	Study 3	IB105 Level 1	ISQG-Low	ISQG-High
As	10-16	9	7-15	20	20	70
Cd	<1-2	1	<1-2	3	1.5	10
Co	--	10	8-10	100	--	--
Cr	18-33	11	10-23	50	80	370
Cu	30-59	35	30-45	100	65	270
Hg	1.6-4.3	--	--	--	0.15	1.0
Mn	--	96	69-75	500	--	--
Ni	6-12	7	6-8	60	21	52
Pb	105-226	113	93-129	300	50	220
Zn	268-698	270	214-336	200	200	410
Tributyltin	11-13	--	--	--	5	70

Study 1: RYCT marina extension sediment and water sampling, Nov 2006 (Marine Solutions, 2006)

Study 2: Ecological assessment at the site of the private jetty, 358 Sandy Bay Rd (Marine Solutions, 2012)

Study 3: Marine Environmental Survey Sandy Bay Jetty Dredging (Aquernal, 2007)

Based on Table 1, the amount of Pb and Zn exceeds the ISQG-Low (International Sediment Quality Guideline) standard and is approaching the ISQG-High standard. Another study called water quality sampling (Marine Solution, 2006) also confirmed this result. Among all the heavy metal pollutants sampled, 80% saturation of Lead and Copper were measured to be approximately 4 and 2 times above the Guidelines (Whitehead J *et al.* 2010). This situation gets even worse after heavy

storms. According to Australian Journal of Earth Science (2003), the industrial outputs (mainly from paper mills and the zinc refinery) accounted for 67% of total heavy metal loads, just followed by the wastewater from the treat plants (22%). Paper production and zinc melting industry are proved to have close relation to the high abundance of Pb, Hg and Zn. Once these heavy metal pollutants are input into the river, they will quickly sink through the water column. Then, they become entrained by

the landward moving bottom current and are concentrated in the middle portion of the river. The upstream accumulation of heavy metals is curtailed by river floods that flush them out of the upper estuary, together with the normal load of river sediment (showed in Fig. 1). Therefore, the concentration of heavy metals in the middle portion of

the river is more evident than other parts. More seriously, some of these heavy metals released in the past would have remained in suspension in the fresher surface water. The combination of these factors aggravates the accumulation of heavy metal pollutants.

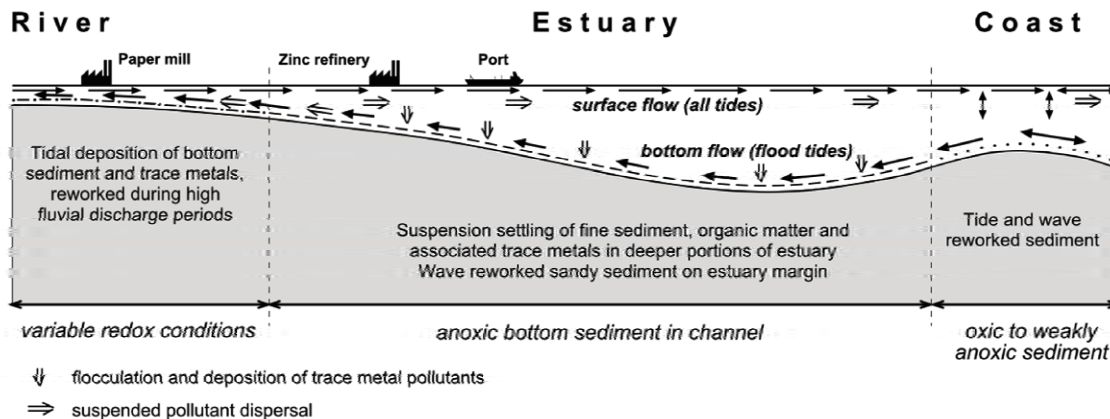


Fig. 1 Sketch outlining the major processes controlling the distribution of pollutants in the Derwent estuary (Source: Jones B G *et al.* 2003)

Besides that, sediments have also been contaminated and become a serious problem. The seabed at the proposed area consists of roughly equal proportions of quality sand, silt sediments (25-65% sediment ≤ 125 μm with 15-40% ≤ 63 μm) and shell fragments (35-75% sediment > 125 μm) (Geo-Environmental Solutions, 2012). This type of seabed sediment is prone to re-suspension, which leads to contaminated components disposed and makes the situation worse. One adverse impact is that suspended sediments may settle out in the reservoir contributed by tributary rejuvenation. Another adverse impact of cumulated sediments is about the water flow speed. There is a close relationship between the level of sediments in the waterway and the water flow speed. The increased amount of suspended sediments will reduce the water flow speed, which accelerates the sedimentation process of toxic material (Wood P L *et al.* 1997).

Fig. 2 shows a clear proportion of suspended sediments in the River Derwent. From the figure, industrial outfall sand wastewater from treatment plants would most likely cause the deterioration of sediment in the river. Besides that, over last decades, contaminated storm water continues to be a significant issue. Fig. 2 shows that excluding the

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influence of river itself, the total amount of contaminated sediment sank at the bottom of the river are still at a dangerous level.

From Fig. 3, Fig. 4 and Fig. 5, the nitrogen load in the river is at a high level; among these nitrogen inputs, WWTPs (Waste Water Treatment Plants) takes a high percentage (around 500 tons every year). Another input cannot be neglected is industrial nitrogen input (mainly from aquaculture activities) because the nitrogen concentration in industrial wastes is 3-6 times than that in treated wastewater. As the figures illustrate, human induced nitrogen inputs (especially in dissolved inorganic nitrogen) doubled the total amount of nitrogen in the river or even more. This has led to structural and functional changes in the system including increased turbidity and reduced transparency in the water. Also, elevated concentrations of nutrients can lead to excessive, often unsightly, growth of aquatic plants. The excessive growth of aquatic plants reduces dissolved oxygen in water and alters stream habitats, both of which are essential for fish and other aquatic life (Marschnert H *et al.* 1997; Smith V H *et al.* 1999). Reduced dissolved oxygen levels can be stressful for all aquatic creatures, especially those living at the sediment-water interface. Low dissolved oxygen

level events tend to be most pronounced. As Fig.6 shows, at most of the sites, the level of dissolved oxygen is below the ANZECC (Australia and New Zealand Environment and Conservation Council)

triggers. This result indicates that marine life in the river mostly live with low oxygen supply, which leads to a decline in the amount of marine life in the river.

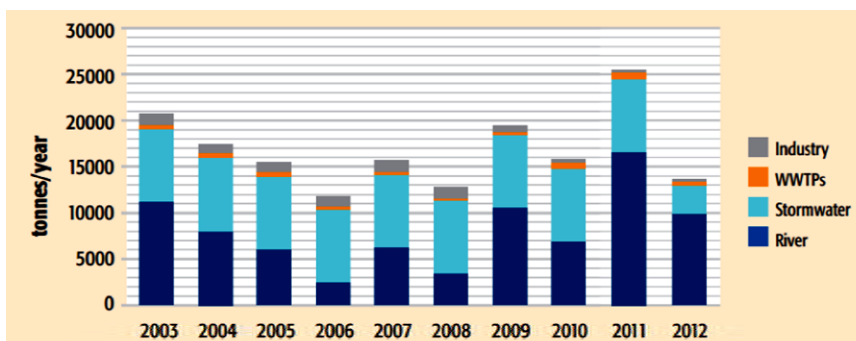


Fig. 2 Total suspended sediments estimated cumulative load (Source: Report card of DEP, 2013)

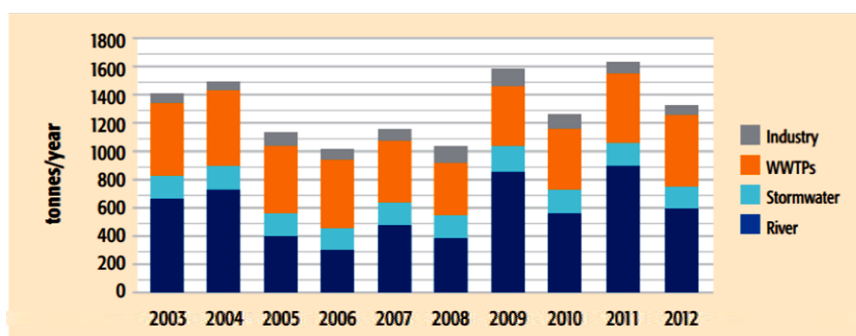


Fig. 3 Nutrients-total nitrogen estimated cumulative loads (Source: Report card of DEP, 2013)

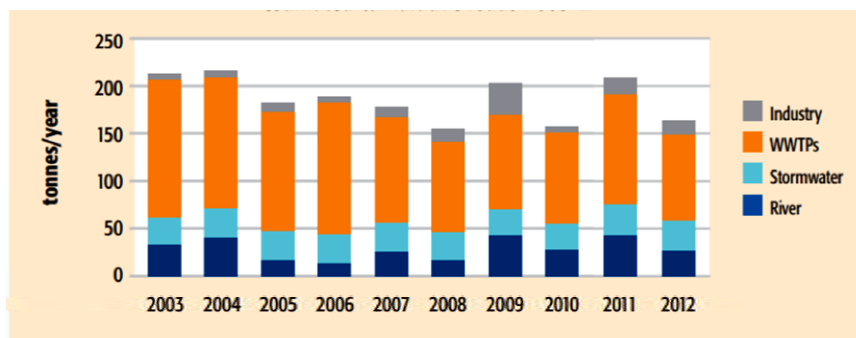


Fig. 4 Nutrient-total phosphorus estimated cumulative loads (Source: Report card of DEP, 2013)

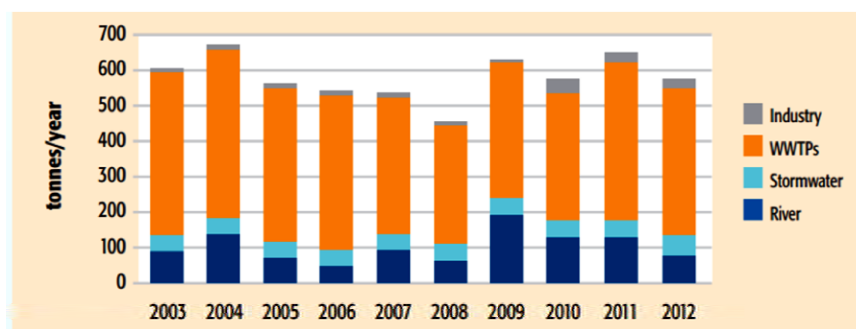
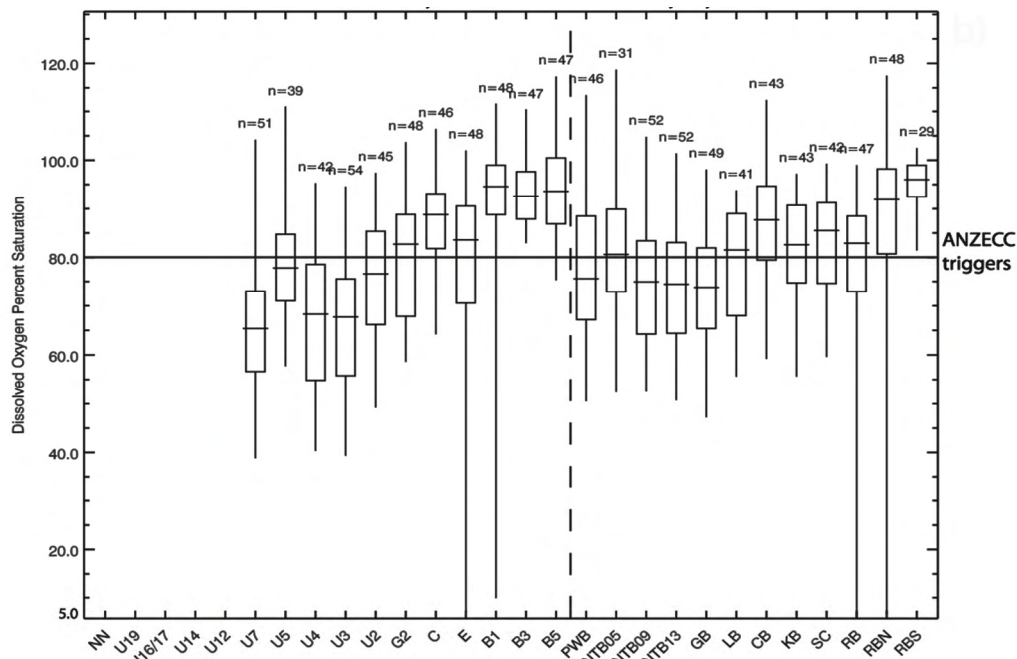


Fig. 5 Inorganic nitrogen estimated cumulative loads (Source: Report card of DEP, 2013)



*NN-RBS represents different water quality monitoring sites in the Derwent estuary

Fig.6 Dissolved Oxygen percentage saturation at bottom or deepest measurement 0.5 m from bottom (Source: DEP report, 2009)

3 Wider impacts

The pollution in the River Derwent has caused disturbance on both the human life and the nature environment. As an instance, the high saturation of heavy metal makes the water undrinkable; tap-water tastes and smells like dirt. Christine Coughanowr, a director of DEP, claimed that water quality has been declining in several areas nowadays, in particular, places around beaches and bays; also there is higher levels of turbidity nutrient and some low dissolved oxygen levels in the upper of the Derwent Estuary between New Norfolk and Bridgewater (Coughanowr C, 2001). More seriously, high level of heavy metals has been found in oysters and mussels, among these heavy metals, in particular, zinc, lead and cadmium comprise the most part of heavy metal components.

Though there is a declining trend in heavy metal contamination in seafood, it still exceeds national food standards. As one of the major impacts by the water issues, DEP directors suggest that public should not eat oysters, mussels and bream from the river. Meanwhile, limiting consumption of flathead and other fish to twice a week at most, has been advised by the public health (Eustace I J, 1974). Particularly, pregnant women,

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breastfeeding women, women planning to become pregnant and children under six are recommended to eat that seafood from the River Derwent no more than once a week. In addition, as the major water supplier in Hobart, the high levels of heavy metals and low dissolved oxygen make the water from the River Derwent smelling and dirty.

Furthermore, the River Derwent is now not available for all water activities, swimming in particular. There are 35 beaches are being monitored each summer to investigate the water quality, which shows that most urban areas are experiencing poor water quality after heavy rain; and during those days, swimming is not recommended. Hobart residents can easily access various sandy beaches, and enjoy water sports including swimming, rowing, water-skiing, windsurfing and boat sailing. However, because of water quality issues, some sites are not suitable for water sports. Water quality at Nutgrove Beach West, Windemere Beach, Hobart Rivulet, Marierville Esplanade, Cornelian Bay, Lindisfarne Bay, Geilston Bay and Brown's River, is detected to be poor; so that swimming and other kind of water sports that would full immerse the whole body are not recommended (Derwent Estuary Program, 2015).

In addition, water pollution in the river is also affecting the natural environment and marine live.

A whole-of-estuary monitoring program coordinated by the DEP integrates sampling carried out by the DEP, Environmental Protection Agency Division, Nyrstar Hobart, Norske Skog and TasWater (Derwent Estuary Program, 2009). The results of this program show a negative trend in water quality in the River. Pollution and dissolved oxygen was at a dangerous stage that can affect the marine life and surrounding biodiversity as well.

4 Conclusions

In summary, despite considerable efforts have been made; water quality in the River Derwent still needs to be improved. This paper highlighted the irreplaceable position of this river and expounded its complex use status. It also illustrated the major contaminations detected from the different sites along the river. The water quality is sensitive and easily influenced not only by human activities but also by natural variables. From these results, it is conceivable that water pollution is a complex issue for multiple reasons and on multiple scales. Once the water environment has been polluted, it would take long term and considerable efforts to rejuvenate. The River Derwent thus can be used as a typical case in dealing with water issues throughout the world.

References

- Aquatic Science. 2007. Review of sediment sampling program: Tasmanian boat maintenance and repair facilities. Hobart: Environment Protection Authority.
- Coughanowr C. 2001. Nutrients in the Derwent Estuary catchment. Final report to the natural heritage trust. Hobart: Department of Primary Industries, Water and Environment.
- Derwent Estuary Program (DEP). 2009. Derwent Estuary sediments, Derwent Estuary report. Hobart: Derwent Estuary Program.
- Derwent Estuary Program (DEP). 2013. State of the Derwent, Year 2013 report card. Hobart: Derwent Estuary Program.
- Derwent Estuary Program (DEP). 2015. Summer monitoring. Hobart: Derwent Estuary Program.
- Eustace I J. 1974. Zinc, cadmium, copper, and manganese in species of finfish and shellfish caught in the Derwent Estuary, Tasmania. *Marine and Freshwater Research*, 25(2):209-220.
- Geo-Environmental Solutions. 2010. Marine environment survey proposed Marina Derwent sailing squadron. Hobart: Geo-Environmental Solutions.
- Geo-Environmental Solutions. 2012. Marine environment survey proposed Marina Derwent sailing squadron. Hobart: Geo-Environmental Solutions.
- Heavy Metals Project. 2015. About the Derwent Estuary & it's heavy metal legacy.
- Hobart City Council. 2009. State of the environment report. Hobart City Council, 5(1):48-53.
- Jones B G, Chenhall B E, Debretsion F *et al.* 2003. Geochemical comparisons between estuaries with non industrialised and industrialised catchments: the Huon and Derwent River estuaries, Tasmania. *Australian Journal of Earth Sciences*, 50(5):653-667.
- Marschnert H, Kirkby E A, Engels C. 1997. Importance of cycling and recycling of mineral nutrients within plants for growth and development. *Botanica Acta*, 110(4):265-273.
- Smith V H, Tilman G D, Nekola J C. 1999. Eutrophication: impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems. *Environmental pollution*, 100(1): 179-196.
- Whitehead J, Coughanowr C, Agius J, *et al.* 2010. State of the Derwent Estuary 2009: a review of pollution sources, loads and environmental quality data from 2003-2009. Tasmania: Derwent Estuary Program.
- Wood P L, Armitage P D. 1997. Biological effects of fine sediment in the lotic environment. *Environmental Management*, 21(2):203-217.