

WASTEWATER FROM SMALL COMMUNITIES AND IMPACTS TO ESTUARINE WATER QUALITY USED FOR AQUACULTURE

P M Geary

School of Environmental & Life Sciences, The University of Newcastle, NSW 2308, Australia.

phil.geary@newcastle.edu.au

J H Whitehead

School of Environmental & Life Sciences, The University of Newcastle, NSW 2308, Australia.

joe.whitehead@newcastle.edu.au

Abstract

In recent years, oyster harvesting in a number of rivers, estuaries and coastal lakes on the mid-north coast of NSW in Australia has been adversely impacted by reduced water quality. Since 1997 Wallis Lake, Tilligerry Creek, part of the Port Stephens estuary, and more recently the Kalang River, have been closed to oyster harvesting. In particular, following periods of heavy rain, water quality in the estuaries has diminished and a number of incidents of pathogen contamination of estuarine waters have occurred. Such incidents have significant adverse impacts on the oyster industry and may result in long periods of closure to harvesting with consequent implications for oyster supply and the livelihoods of those employed in the oyster industry. On-site wastewater management systems (OWMS) on properties close to the estuary have often been considered possible sources of contamination of estuarine waters.

State Government agencies have broad responsibilities for public and environmental health and in the oversight of shellfish quality, whilst local Councils are responsible for the approval and ongoing operation of OWMS. Studies by the authors and State Government agencies such as the NSW Food Authority and local Councils such as Port Stephens have attempted to use a range of methods to demonstrate connectivity of failing OWMS to the estuaries. Systematic audits of these systems in some catchments have quantified the extent to which these systems do not meet current regulatory requirements and have been used to develop a risk based approach to assessment of the wider extent of the problem. Pathogen die-off modeling has been used to assess risk and determine the need for upgrading or replacement of existing OWMS. Standard designs have been developed and implemented in some catchments to ensure a higher level of OWMS performance and there is clear evidence that, where these designs have been implemented, impacts have been reduced.

Keywords: On-site wastewater management systems, estuaries, New South Wales, pathogens, tracers, aquaculture.

INTRODUCTION

Wastewater management in small communities may involve a reticulated system with centralised treatment and disposal or in some cases reuse of the treated effluent. Where the cost of a reticulated system is prohibitive to small communities, wastewater may be treated and disposed of on-site at individual properties. Typically in these on-site situations, a septic tank and land application system involving subsurface trenches or beds may be used. Surveys and audits of OWMS and their performance in Australia often demonstrate that a substantial proportion perform poorly or fail due to poor construction, undersizing with respect to hydraulic loads or soil and land capability constraints for on-site effluent disposal. Where these failures occur there is concern with respect to public health and the environment. There are however very few studies which are able to demonstrate direct linkages between these OWMS failures and adverse impacts to human health and receiving waters. The inability to discern such linkages and widespread contamination which may be anticipated is partly due to effluent dilution, the difficulties which exist in differentiating effluent pathways in the field and the attenuation of faecal contaminants.

In NSW there have been a number of highly publicised cases of contamination of estuarine waters used for oyster growing along the coastline north of Newcastle. In each case possible sources of human faecal and nutrient pollution have been found to come from agricultural areas, waterway users, runoff from urbanised areas and unsewered small communities. It is very difficult to separate the overall impact that these small communities have to estuarine water quality in comparison with agriculture, however where human viruses are found in estuarine filter feeders such as oysters, a human source of contamination has to be acknowledged.

In January 1997 in Wallis Lake, a *Hepatitis A* virus affected approximately 274 people in NSW (one fatally), and in all, 422 people throughout Australia. In a subsequent investigation by NSW Health, it was concluded that the oyster contamination was waterborne and potentially from contamination by human faecal waste (Kardamanidis *et al.* 2009). While the estuarine waters were contaminated by human faecal and nutrient pollution from unsewered small communities and other sources, the specific source of the waste was not able to be determined. Failing OWMS were however considered highly likely to have been primarily responsible due to their reported high rates of failure and the large number of unidentified unsewered premises in the catchment.

In July 2005 part of the State's second largest producer of oysters with an annual value of A\$5 Million (behind Wallis Lake with an annual value of A\$14 Million) was closed to commercial oyster harvesting due to a similar contamination incident. Samples of oyster tissue tested positive using PCR analysis for human Adenovirus and Norovirus in the Tilligerry Creek estuary in Port Stephens. In this case (as in Wallis Lake), faecal contamination from failing OWMS was considered responsible, although agricultural sources of contamination were also significant in terms of the overall faecal load to the estuary. The estuary remained closed to commercial harvesting for over two years resulting in a substantial loss of income from which the industry in that region has yet to recover.

More recently in 2008 outbreaks of gastroenteritis have been linked to a common batch of oysters harvested from the Kalang River estuary in northern NSW. The presented symptoms were consistent with Norovirus infection and the estuary subsequently closed to the commercial harvesting of oysters by the NSW Food Authority which manages the State's Shellfish Program. Investigations are still underway as to the source or sources of the human faecal contamination and the estuary still remains closed to harvesting. Possible human sources of the contamination are considered to be a number of OWMS adjacent to the estuarine waters and a downstream sewerage treatment plant discharge from a nearby community's wastewater system.

METHODS AND RESULTS

In response to the outbreak in the Wallis Lake estuary, a number of local and state government agencies collaborated in estuary and catchment remediation works. Over the 13 years since the incident, these works have resulted in significantly improved estuarine water quality and commercial oyster growing is again thriving. In 2004 the Great Lakes Council was awarded a major prize for best practice in river and catchment management and environmental repair in Australia (Kardamanidis *et al.* 2009), although the actual source of the contamination incident has never been identified.

In response to the closure of the Tilligerry Creek estuary to oyster harvesting, a sanitary survey of the estuary and river shorelines was conducted by the NSW Food Authority and Port Stephens Council undertook OWMS inspections. An audit of approximately 300 OWMS in the community adjacent to the estuary found that a small number of systems were faulty and that human effluent had the potential to contaminate ground and surface estuarine waters where the oysters were grown and harvested. In this study a number of individual OWMS were dosed using bromide and lithium salts and fluorescein dye to determine whether direct linkages existed between the OWMS and surface and groundwaters. In several of these cases hydraulic pathways to the estuary were confirmed indicating that contaminated groundwater from OWMS was entering surface drains and quickly entering the estuary following heavy rainfall events (Geary, 2005). More detailed investigations followed to identify the sources of faecal contamination that an unsewered development was making to both surface runoff and groundwater entering the estuary. In addition to the microbial faecal indicators regularly used in such studies, water samples were collected and analysed for faecal sterol compounds in order to determine whether faecal contamination was human-derived. Interpretation of the various sterol compounds indicated that while there had been occasions where human-derived faecal contamination had entered the estuary, the majority of the faecal contamination at that time was derived from herbivores in the catchment upstream (Geary *et al.*, 2007).

While the estuary was closed, estuary and catchment remediation works were initiated by the local Council. A catchment management plan was commissioned which recommended a number of improved management practices be adopted and an estuary response model developed. When a sewerage options study indicated that the cost of a reticulated system for the small community adjacent to the

estuary was prohibitively expensive, a number of standard designs for improved OWMS were developed (Whitehead & Associates, 2005) and failing systems were required to be upgraded. One of the OWMS designs adopted by Council which has proved very successful in overcoming the problems associated with the high groundwater table is the sand (Wisconsin) mound. These systems are considered secondary treatment systems as primary treated effluent is pumped into an above ground distribution system constructed in imported permeable soil. Effluent then percolates through this material where treatment occurs prior to it entering the groundwater. As a mitigation measure, 58 mounds which receive primary treated effluent and nine which receive secondary treated effluent from aerated treatment systems have been constructed. Monitoring has shown that the overall efficacy of the treatment system can be directly linked to the increased vertical separation distance to the groundwater provided by the mound and the periodic dose loading of effluent from the septic tank (Whitehead and Geary, 2009).

Similar audits conducted in the Kalang River estuary have found that a number of OWMS which have been approved by the local Council are failing. Studies have been undertaken using tracers such as fluorescein, rhodamine and bromide, along with microbiological faecal indicators, to determine the source of the human contamination in the estuary waters. There are unsewered and sewerred urban settlements adjacent to the river and a variety of other agricultural land use activities upstream which may be contributing to the faecal contamination detected in these oyster growing areas, however the source of the human contamination has yet to be found and the estuary remains closed to oyster harvesting. This situation, as in the former example, has had a profound effect on the commercial viability of the oyster growing industry in each of these estuaries.

CONCLUSIONS

Demonstrating direct linkages between the wastewater management practices of small communities and estuarine water quality is difficult at the catchment scale and may not be possible using standard monitoring techniques and microbiological indicators. Incidents such as those discussed above demonstrate the close relationship and the sometimes inherent conflict between managing wastewater in small communities, increasing urban and rural development, and the need to maintain estuarine water quality so that aquaculture such as oyster growing can be undertaken without compromising human health.

REFERENCES

- Geary, P.M. (2005). Effluent tracing and the transport of contaminants from a domestic septic system, *Wat.Sci.Tech.*, 51(10), 283–290.
- Geary, P.M., Lucas, S.A., Dunstan, R.H. and Coombes, P.J. (2007). Distinguishing wastewater contamination from on-site systems in mixed land use watersheds, In 11th National Symposium on Individual and Small Community Sewage Systems Proceedings (Ed. K. Mancl), American Society of Agricultural Engineers, St. Joseph, Michigan.

Kardamanidis, K., Corbett, S.J. & Zammit, A.P. (2009). Hepatitis A: Wallis Lake revisited, NSW Public Health Bulletin, 20(1–2), 29–30.

Whitehead & Associates (2005). Standard Designs for On-site Wastewater Management Systems in Tilligerry Creek. Prepared for Port Stephens Council. (<http://www.portstephens.nsw.gov.au/environment/44034/44052.html>)

Whitehead, J. and Geary, P. (2009). Sand mounds for effective domestic effluent management, Water, 36(1), 27–32.