PUMPING OUT THE PROBLEMS: WASTEWATER TREATMENT INHIBITION FROM PORTALOO PRODUCTS

Cady Burns, The Wastewater Specialists *August 2023*

The portable toilet, otherwise known as a 'portaloo', is widely used at public events as well as construction sites. An essential component of this service is portaloo upkeep and cleanliness, where waste is removed and a range of products are used to deodorise and sanitise, often leaving a distinct odour and colour behind to mask the sight and smell of the waste. The portaloo waste is often discharged into a municipal wastewater treatment plant (WwTP). Portaloo products have the potential to inhibit biological wastewater treatment processes.

This research addresses a knowledge gap about the possible toxicity of portaloo products within a biological WwTP. Using respiration based toxicity testing (RBTT), portaloo products commercially available in New Zealand were tested for potential inhibition. The results of this testing are presented in this paper.

This project has several important implications for both WwTPs and Te Mana o te Wai. There is an increasing importance for the chemicals we use to be environmentally friendly, and Te Mana o te Wai is encouraging higher standards for wastewater treatment to improve environmental outcomes. As our population grows, we will put more of a strain on the wastewater system, therefore we must understand the affects that different chemical inputs may have. This project is not only important for environmental protection strategies and policies, but also for public health. Furthermore, this paper assists industry, providing important insight on the environmental impact of the products used.

KEYWORDS

Portaloo products, Wastewater treatment, RBTT, inhibition.

PRESENTER PROFILE

Cady Burns is a dedicated and enthusiastic student pursuing a Bachelor of Science degree. Additionally, Cady works for The Wastewater Specialists, where she has gained valuable experience in wastewater treatment. Cady is determined to make a positive impact in the water industry and promote sustainable water management practices.

INTRODUCTION

Biological processes are utilised in all WwTPs to break down pollutants in the wastewater, assisting in the conversion of contaminants to less harmful substances (Davies, 2005). The biomass in a biological wastewater treatment process, which consists of bacteria, protozoa, and microscopic animals, is essential for the breakdown and removal of nutrients, organic debris, and various pollutants (Bitton, 2011).

In wastewater treatment, two main types of bacteria are utilised; nitrifying bacteria, also known as nitrifiers, that convert ammonia to nitrate, and heterotrophic bacteria, that break down organic contaminants (Gerardi, 2006). The amount of oxygen required to break down pollutants in wastewater is measured as biochemical oxygen demand (BOD). Activated sludge, trickling filters, rotating biological contactors, and oxidation ponds are all forms of biological wastewater treatment that break down BOD to different degrees (Gerardi, 2006). Ammonia is a compound found in urine and decaying organic materials (Stevenson, n.d.). High ammonia levels can be detrimental to aquatic life as well as nitrifiers (Grey, 2004). Nitrification is a significant biochemical step in wastewater treatment because nitrate is less toxic to aquatic life than ammonia (Bitton, 2011). Considering that heterotrophs and nitrifiers are predominantly aerobic bacteria, dissolved oxygen (DO) is utilised by biomass in aerobic treatment processes. Aerobic bacteria that are healthier and more active use oxygen at a higher rate than unhealthy bacteria (Grey, 2004). As a result, the rate of oxygen consumption, known as the oxygen uptake rate (OUR), can be used to indicate the health of the biomass.

To explore the potential inhibition of discharges to WwTPs, respiration-based toxicity testing (RBTT) can be applied. The potential inhibitory effect of a discharge is assessed through RBTT by monitoring biomass OUR. The procedure for performing RBTT is defined in the OECD's *Guidelines for Chemical Testing: Activated Sludge, Respiration Inhibition Test (Carbon and Ammonium Oxidation)* (OECD, 2010).

Products containing a wide variety of chemicals are commercially available in New Zealand, of which many find their way into the wastewater system. These chemicals, or their metabolites, such as heavy metals, pesticides, and industrial solvents from domestic and/or industrial wastewater, have the potential to be harmful to the environment. Some chemicals, especially at higher concentrations, can be toxic to, or inhibit, biomass, lowering the efficiency of wastewater treatment processes (Bitton, 2011). This is particularly significant when dealing with a small or sensitive WwTP.

PORTALOO PRODUCTS

Products used for deodorising and sanitising portaloos in New Zealand were identified, some of which are widely used by the industry, and others that are available in hardware stores.

Through industry engagement the project successfully surveyed 32 portaloo operators throughout New Zealand. Five products were identified as being used

commercially (Walex Porta-Pak, Walex Bio-Pak, Fluid Chemicals Novirusac, PolyJohn Power packets, and PolyJohn Poly-Blue plus). Furthermore, with other research, four additional products sold and marketed for portable toilets were identified and tested (BioMagic, SCA portable toilet cleaner, Portasol toilet cleaner by Chemtech and Clark Loo Blue). These came in a variety of forms, colour, and odour, each with their own list of ingredients.

By testing these nine identified deodorising and sanitising products at the manufacturers recommended dilutions (Table 1), a comparative outcome could be made. This comparison can aid in decision making when it comes to deodorising and sanitising portable toilets.

Table 1: Products tested showing their form and manufactures dilution recommendations supplied either from company, importer or manufacturers.

Company / importer	Product name	Dilution guidelines	Form
Walex products company INC	Porta-Pak	0.215 g/L	Powder
Walex products company INC	Bio-Pak	0.191 g/L	Powder
Fluid Chemicals New Zealand	3466 -Novirusac Gel	2.5 ml/L	Liquid
Clark products Ltd	Clark Loo Blue	12.5 ml/L	Liquid
Chemtech	Portasol toilet chemical	5 ml/L	Liquid
Super cheap auto	SCA portable toilet chemical	6.65 ml/L	Liquid
BioMagic INC	BioMagic	3 ml/L	Liquid
PolyJohn	Power packets	0.215 g/L	Powder
PolyJohn	Poly-Blue plus	0.215 g/L	Powder

RESPIRATION BASED TOXICITY TESTING

The biomass from each WwTP is unique, and contains a diverse range of organisms. Nitrifiers contribute to OUR due to the aerobic process of nitrification. Biomass was acquired from wastewater treatment plants containing a significant proportion of nitrifiers for RBTT testing as part of this research, giving confidence in the RBTT approach.

In respiration based toxicity testing (RBTT), the inhibition of nitrifying bacteria is separated from the inhibition of the total biomass. This is important because nitrifying bacteria are typically more susceptible to inhibition than heterotrophic bacteria, and nitrifiers play a crucial role in nutrient removal. This separation of the inhibitory effect on nitrifying bacteria from inhibition of the general biomass is performed by running one set of experiments which includes the total biomass from an activated sludge plant, then repeating the tests with the same biomass

after adding a nitrification inhibitor, in this case, allylthiourea (ATU), which is commonly used for this purpose.

RESULTS

The Portaloo survey provided insight on the dilution standards of portaloo products used throughout the industry. It was found that, on average, the concentration of these products in a portaloo were higher than the manufacturers recommended dilutions due to two major factors. Firstly, service rosters providing clean and sanitary toilets lead to portaloos being emptied before full dilution is achieved. Secondly, some portaloo operators reported using increased concentrations of products, with reports of up to double the recommended dilution being used to mask the smell and visual appearance.

Testing each product at their recommended dilutions identified potential inhibition not only of the nitrifying bacteria but also the total, heterotrophic plus nitrifying, biomass. The results from our RBTT are summarised in Figures 1 and 2. Each product was tested on at least three separate occasions, with the inhibition results shown being an average of the results for each product.

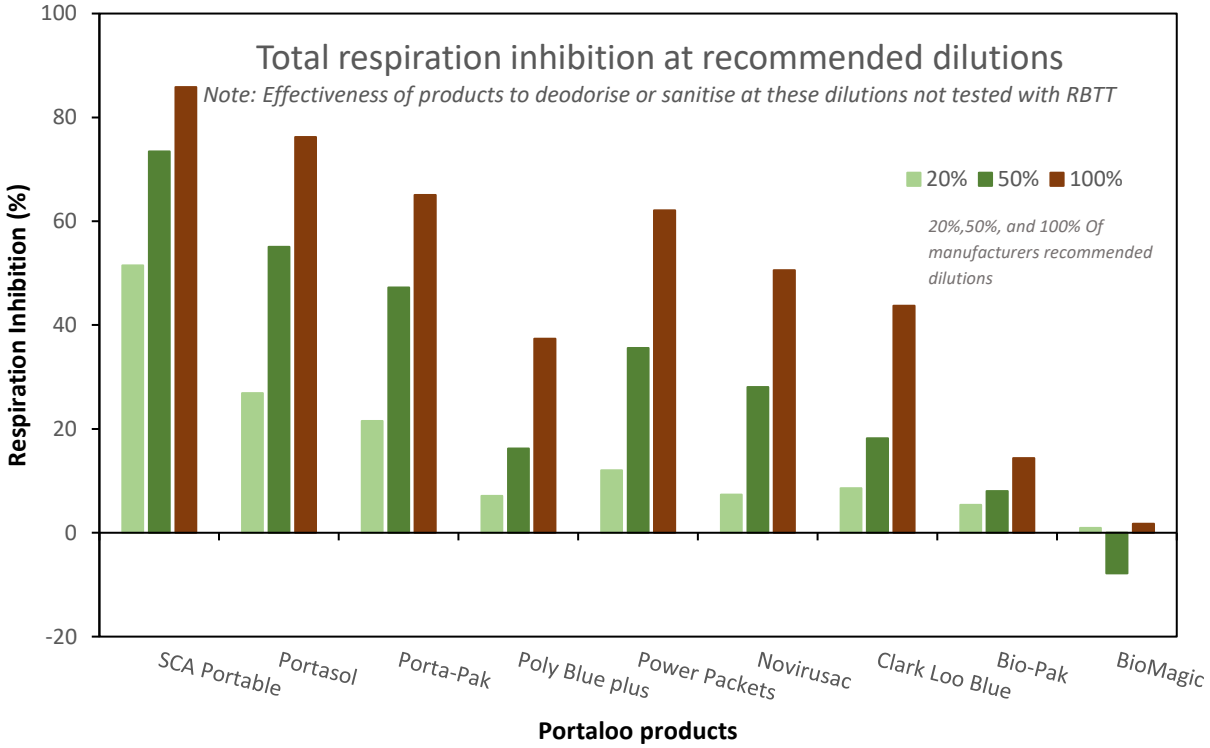

Figure 1: Respiration inhibition tested using RBTT, showing 20%, 50% and 100% concentrations, using manufacturer recommended dilutions for portaloo products.

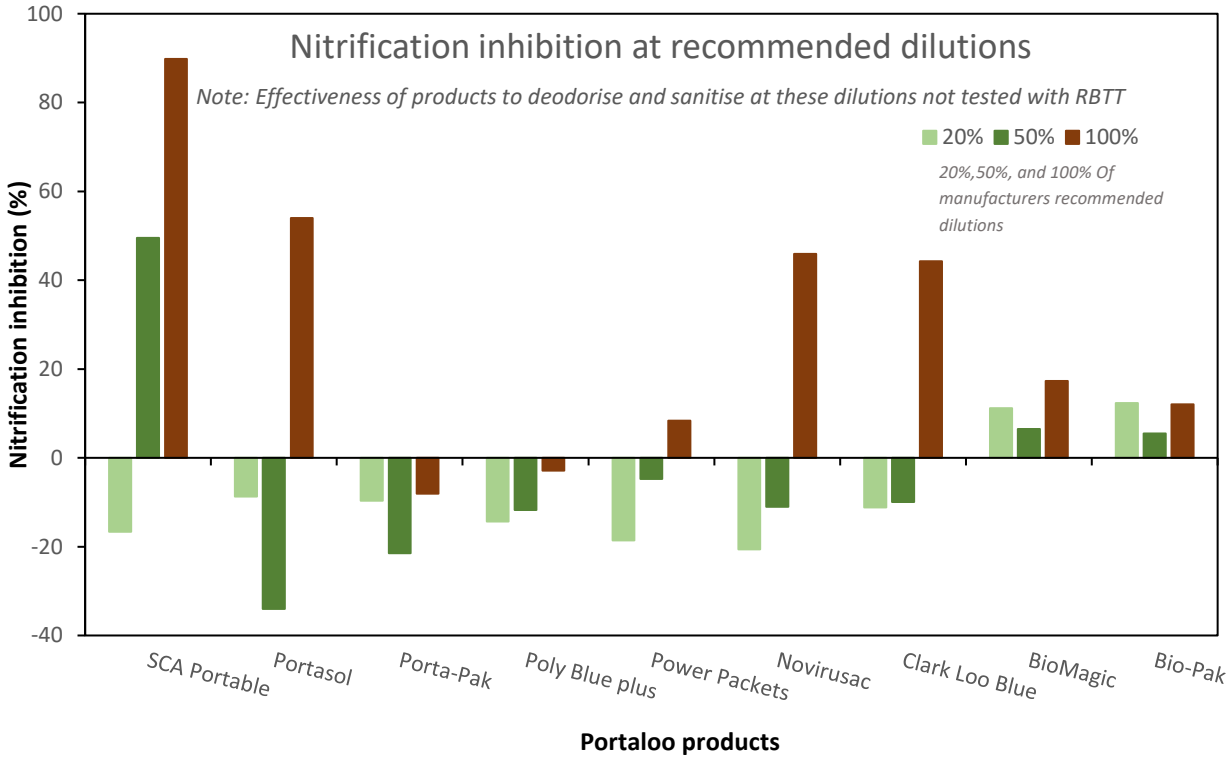

Figure 2: Nitrification inhibition tested using RBTT, showing 20%, 50% and 100% concentrations, using manufacturer recommended dilutions for portaloo products.

Results (Figure 1) show that most products had an inhibitory effect on the total biomass, with SCA portable showing highest inhibition and BioMagic showing the least inhibition towards the total biomass at manufacturers recommended dilutions. Many other products resulted in an increased OUR by nitrifying bacteria (Figure 2) at manufacturers recommended dilutions (Table 1). SCA portable toilet cleaner caused the most inhibition towards the nitrifying bacteria and Walex Porta-Pak showed the least overall inhibition at 50% and 100% of manufacturers recommended.

DISCUSSION

Respiration based toxicity testing was undertaken on a variety of portable toilet products available for use in New Zealand, which were each diluted according to their manufacturer's recommendation. These comparisons determined the inhibitory effects of the products on the general heterotrophic biomass as well as on the important nitrifying biomass.

It is important to note that this study only looked at the potential inhibition of portaloo products on WwTP biomass at the manufacturers recommended dilution rates, not whether the products were effective at performing their intended function (sanitising and deodorising) at these dilutions. As a result, if RBTT results indicate a product would have a low impact on biological wastewater treatment processes, this does not necessarily mean the product would be the best product to use. i.e. it may not be fit for purpose.

The most significant and noteworthy findings obtained, from an industry perspective, was that the nitrifying bacteria were not as inhibited by the products as the total biomass. Surprisingly, Walex Porta-Pak and PolyJohn Poly-Blue Plus had negative inhibition towards the nitrifying bacteria overall. Although it would be ideal if both the general (heterotrophic) biomass and the nitrifying biomass had little or no inhibition, this outcome is favorable because nitrifying bacteria require more time to recuperate and are more significant when it comes to nutrient removal. The general heterotrophic biomass multiplies at a faster rate, and therefore recovers more quickly, than the nitrifying bacteria population. This means any inhibition of the heterotrophic biomass is less significant than inhibition of the nitrifying bacteria.

Our survey of portaloo operators revealed that PolyJohn Power Packets, PolyJohn Poly-Blue Plus and Walex Porta-Pak were generally considered to be the same product, branded by different companies, therefore these products are sometimes used interchangeably by the industry. However, the results of our RBTT testing indicate that Poly-Blue plus and Power Packets are, in fact, different products. Furthermore, while there were some similarities with Porta-Pak and Power Packets, slight differences in odour further suggest these products are, in fact, different.

Although BioMagic and Walex Bio-Pak showed the least overall inhibition to the general biomass, as could be expected given their environmentally friendly marketing, the effectiveness of a product also needs to be considered. During the survey of portaloo operators, one company explicitly stated they were dissatisfied with the effectiveness of the environmentally friendly alternative, resulting in a product change from Walex Bio-Pak to Walex Porta-Pak.

One product, in particular, was more inhibitory to wastewater treatment biomass at the suppliers' recommended dilution than other products. SCA portable toilet cleaner had high inhibition on both the general biomass and the nitrifying bacteria. Secondly, Portasol toilet cleaner showed the second most inhibition to the general biomass. Portasol toilet cleaner, Clark Loo Blue and Novirusac had relatively similar results in higher concentrations in regard to nitrifying biomass inhibition.

Even though prompt servicing and increased product concentrations may deliver a more pleasing portaloo experience, it would result in higher concentrations of portaloo products within the portaloo waste discharged at municipal WwTP's. Therefore, the inhibitory effect of portaloo waste on WwTPs may, in fact, be greater than suggested by this testing.

Toxic substances can decimate the biology in a WwTP and impact the receiving environment. This biology holds intrinsic value to environmental processes. Optimising wastewater treatment processes will help to achieve any more stringent discharge standards required to meet Te Mana o te Wai.

Effects of these products on biological treatment processes may differ depending on WwTP type. The two most common types of biological wastewater treatment processes used in New Zealand are oxidation ponds and activated sludge. Table 2 outlines the differences between the two.

Table 1: WwTP comparisons between oxidation ponds and activated sludge.

Parameter	Oxidation Pond	Activated sludge
Hydraulic retention time	40 - 50 days	6 - 12 hours
Biomass type	Algae + bacteria	Bacteria
Biomass concentration	Low (passive)	High (active)
NZ temperature (°C)	5 - 25	12 - 25

Many factors influence the effectiveness of WwTP processes, of which temperature plays a key role. Oxidation ponds operate closer to ambient temperature than activated sludge plants, which leads to seasonal variations in biomass composition and pond performance. This fluctuating biomass and performance needs to be considered when assessing the potential impact of chemicals on treatment processes. Temperature is important because of its effect on growth rate and survival of nitrifying bacteria. Below ~8°C the growth rate of nitrifiers is very slow (Water NZ, 2017). Conversely, the temperature in activated sludge plants is more stable, and activated sludge is a higher intensity process which can lead to more resilient biomass and, therefore, a higher resistance to inhibition. One advantage to Oxidation ponds is their size, leading to potentially greater dilution resulting in lower overall impact. The optimum temperature range for the nitrifying bacteria in a WwTP is between 25 °C to 40 °C, therefore, the warmer winter temperatures of activated sludge plants make them more resistant to process upsets.

Additionally, other incoming and potentially inhibitory wastewater discharges can either have a compounding, antagonising or synergistic effect. Therefore, the discharge of portaloo waste to a municipal WwTP should be considered alongside other factors. What level of dilution is available, and what other potentially inhibitory wastes are also discharged to the WwTP for treatment? For example, a large festival or sporting event hosted in a small town would result in a proportionally more significant load of portaloo wastewater to the WwTP.

CONCLUSIONS

It was found that some products do indeed have the potential to inhibit biological wastewater treatment processes more than others. Results showed that SCA portable toilet chemical had the most inhibitory effect on the general biomass at the manufacturers recommended dilution. Results also confirming that portaloo products marketed as being environmentally friendly are less likely to inhibit biological wastewater treatment processes, however, based on feedback from portaloo operators, such products may not be as effective at deodorising or sanitising waste.

Inhibition of portaloo wastes on WwTPs have the potential to be greater than indicated in this research due to the fact that the amount of product in portaloo waste discharged to WwTPs may be higher than recommended by suppliers.

Inhibition towards the biomass is incredibly important when it comes to WwTP optimisation and effectiveness, not only from a functional point of view but also an ecological point of view.

The effect of portaloo waste on an individual WwTP will be influenced by the type of biological treatment processes used, the dilution available, and the nature and quantity of other non-municipal discharges to the WwTP. When assessing the impacts of entering wastewater and its constituents, the size and type of WwTP must be considered. It is recommended that prospective management measures, such as load spreading, should also be considered.

ACKNOWLEDGEMENTS

We would like to thank Water New Zealand who endorsed this project and encouraged, through the pipeline newsletter, their members to contribute. We would also like to thank The Trade and Industrial Waste forum for also encouraging their members to contribute. Additionally, Gary Soper, from New Plymouth District Council, for recommending that portaloo operators in the New Plymouth district take part in this project. We also extend our appreciation to the companies who took part in this research and wish to remain anonymous, and to the following companies who took part in this research and wish to be acknowledged; Matamata Hire, Dalley's Dunnies, Superloo, SJ Allen, Awamoa Sanitations, Toilets and Tents, Bob's Takeaways and Hireworks. This participation has been instrumental for the study and we are grateful for your time.

REFERENCES

Bitton, G. (2011). Wastewater microbiology (4th ed.). Wiley-Blackwell. https://doi.org/10.1002/9780470901243

Davies, P. S. (2005). The Biological Basis of Wastewater Treatment. https://www.strathkelvin.com/wp-content/uploads/2014/11/the-biological-basis-of-wastewater-treatment.pdf

Gerardi, M. H. (2006). Wastewater bacteria. Wiley-Interscience.

Grey, N. (2004). Biology of Wastewater Treatment. https://doi.org/10.13140/RG.2.1.4598.8003.

Metcalf & Eddy (2004); Wastewater Engineering: Treatment and Reuse (Fourth Edition); McGraw-Hill, 559.

OECD. (2010). Test No. 209: Activated Sludge, Respiration Inhibition Test (Carbon and Ammonium Oxidation). https://doi.org/doi:https://doi.org/10.1787/9789264070080-en

Stevenson, D. (n.d.). Ammonia, Water treatment challenges. In N. Smalberger (Ed.).

Water New Zealand (2017); Good Practice Guide for Waste Stabilisation Ponds: Design and Operation; November 2017