Leachate from Tyres – Exploring the Myths

Eric Claus
Claus Environmental Engineering

Keywords: tyres, leachate, tyre derived products, water pollution

ABSTRACT

About 20 million tyres reach the end of their useable life in Australia each year. There are obstacles to landfilling tyres, so there are incentives to find effective methods of recycling tyres. Several methods have been developed for recycling tyres, but there has been resistance due to concerns about water pollution from recycled tyre products. These concerns began in the early 1980's when recycled tyre products were first being considered for large scale applications. Laboratory research showed that under conditions where very high concentrations of tyre leachates were generated, some species of fish died. The researchers themselves cautioned against making sweeping conclusions based on this initial research, but these sweeping generalisations have persisted. Two myths are explored. The first is that tyre water kills fish. Using some of the same data that has been used to perpetuate the myth, it can be shown that the kind of conditions created in the lab do not occur in the natural environment, so there is little risk of tyre water killing fish. The second myth is that tyre leachates could be a significant environmental problem. Since hundreds of times more tyre material gets into the aquatic environment from road runoff than from tyre leaching, the impact of leachates must be hundreds of times less than the impact of road runoff.

1. INTRODUCTION

The equivalent of about 20 million passenger car tyres were disposed of in Australia in 2003. The number has risen with the rise in Australia's population and affluence, and is likely to continue to rise.

The durability, strength and toughness of used tyres means that they cannot be disposed of in the way that 99% of the solid waste in Australia is disposed – landfill. Most solid waste can be crushed and compacted with the earthmoving equipment used at landfills. Even the largest specially built equipment at the biggest landfills, is ineffective on tyres.

Since tyres can't be landfilled in their original condition, they must be processed to allow landfilling. The strength and durability of tyres makes breaking or shredding them to smaller pieces, relatively expensive. This expense can lead to dumping and illegal stockpiles which leads to the most serious environmental problems with scrap tyres – fires and vermin. The NSW EPA has recognised the difficulty in disposal of used tyres by including used tyres as a priority waste in its Extended Producer Responsibility (EPR) program.

> "EPR is generally applied to post-consumer wastes which place increasing physical and financial demands on municipal waste management." (NSW EPA 2003)

Scrap Tyres have a terrible image environmentally. The image is enshrined in the cartoon “The Simpsons” in which the town’s tyre dump fire burns 365 days per year and is considered a local landmark. Much of the poor image is based on poor management, but it is difficult to distinguish the tyre from the management, so the image remains.

2. RECYCLING OPTIONS

Wouldn’t it be great if there was some good way of getting rid of all these tyres and taking the strain off the waste management system. Wouldn’t it be even better if the tyres could be used in some positive manner so that the strength and durability of the tyres could be put to good use and another virgin material would not have to be manufactured. All the greenhouse gases, water and air pollution of manufacturing the virgin product would be spared from the environment and the impacts of the tyre as waste would also be spared.

Several options, for tyre derived products that can replace virgin products in civil engineering applications such as walls, scour mats and road pavements, are available on the market. While there are obvious life cycle advantages in replacing a virgin product with a product that would otherwise be a waste, the drawback with tyre derived products seems to be the threat of water pollution.

3. REGULATORY OPINIONS

The NSW EPA has produced a document entitled “Consultation Paper: Extended Producer Responsibility Priority Statement” in February 2003. In the section of Appendix 1 – Supporting Fact Sheets- Used Tyres under the heading Environmental and/or health impacts, the report states:

> “Problems include . . . . ; pollution of waters by chemicals leaching from dumped tyres
>
> Used tyres that have been in water for 1.5 years continue to leach a variety of chemicals which adversely affect the organisms in the surrounding environment. After 10 years’ exposure, however, leachates from the tyres are no longer toxic.” (NSW EPA 2003)

Any regulator in NSW would certainly be expected to understand from the states environmental authority, the NSW EPA (now the DEC), that tyres were bad because they leached bad chemicals.

The Atech Group (Atech 2001) has prepared a report for Environment Australia entitled “A National Approach to Waste Tyres.” Table 6.2 (page 21) lists the environmental impacts of tyres. One of the items in the potential impact column is “Leaching of metals during disposal” and another is “Impacts due to leach/emission from waste tyres”. Section 6.4.2 of the Atech Report is a little less clear on leaching, but would still probably leave doubt in the mind of a careful regulator about whether tyres were safe in civil engineering applications.

> “On one hand, tyres are stable and resist degradation and leaching of the components. On the other hand, tyres do leach both organic and inorganic substances. Abernethy reports that tyres in water are lethal to rainbow trout in certain circumstances.” (Atech, 2001)

If NSW EPA and Environment Australia have concerns about tyre leachate, then it is understandable that Departments of Transportation, Councils and other regulators that have less expertise and less authority in environmental matters, would also have concerns. It is worthwhile exploring the reasons for their concerns.

4. MYTH 1 – "TYRE WATER KILLS FISH"

In the 80's some tyre derived products began to be used in civil engineering applications in North America and Europe. This led to questions about potential environmental impacts from the leachates. In the early 90's researchers took the first step in determining whether there were leachates from tyres. This first step involved putting a tyre in a bathtub or shredding up a tyre and putting the pieces in a bucket. After soaking the tyre or the shreds for between 10 and 90 days, the tyre water was removed and used for toxicity testing on some marine organisms. Most survived, but rainbow trout fry (0.5 to 5.0 grams each) died.

Several researchers emphasized that this was only the first step in testing tyre leachate. As Goudey and Barton (1992) noted:

> "These tests were not designed to be definitive tests, but rather preliminary screening tests to determine the possible extent of toxicity of tire materials." (Goudey and Barton 1992)

Collins et al (1995) included a similar message:

> "This work was designed as a 'worst case' study with very high surface to volume ratios." (Collins et al 1995)

Despite these warnings from the researchers themselves, the message that got to many regulatory agencies was "Tyre water kills fish." Investigating further did not seem necessary. Delving into the intricacies of life cycle assessment and the environmental benefits of using a material that would have to be treated as a waste as a replacement for virgin building materials, is far beyond the brief of most regulatory agencies. The simple thought that "tyre water kills fish" remained in the minds of many regulators.

On closer inspection of the "static tyre water" research, two important aspects of the research are usually not considered by the reviewer. First, there was no consideration of the amount of water that would actually come in contact with the tyres in a civil engineering project. Second, it was assumed that the leaching rates that were present in the first month of the tire soaking, would continue for the life of the project. Careful consideration of either of these aspects would have knocked out the conclusion that tyre water kills fish.

4.1 Dilution of "Tyre Water"

When researchers began making "tyre water" they wanted it to be as concentrated as possible. If the highly concentrated "tyre water" was non-toxic to fish, then there would certainly be nothing to worry about at lesser concentrations.

Scott Abernethy was one of the researchers who did the initial static tyre water lethality testing. His original paper (Abernethy, 1994) included several further questions that he believed needed to be answered. He followed up his 1994 paper with a further series of experiments designed to answer some of the questions that remained after the initial work. Some of those questions involved the effect of dilution. After doing experiments that modelled a stream, with water consistently flowing through the tires at varying rates, Abernethy, et al (1996) reported:

> "The tests showed that the tires were non lethal to trout at a minimum water flow rate of 1.5 litres per minute per 600 litre water volume, a flow less than that provided by most Ontario surface waters. Therefore tires in Ontario waters are not expected to cause acute lethality because of natural dilution." (Abernethy, et al 1996)

Nelson, et al (1994) made a similar observation:

> "While toxicity caused by zinc was observed in laboratory tests, it is unlikely that the zinc concentrations leached from the tyres used in artificial reefs would ever cause acute or even chronic toxicity." (Nelson, et al 1994)

An example of the impact of dilution can be made for a scour protection structure around four 1200mm diameter culverts under a road in Sydney. Assuming the peak 100 year flow would be about $16m^3$/sec, the area to be drained would be about 80 hectares. If there was 800mm of rain per year over that 80 hectare catchment then about 30% is likely to run through the culverts each year. That would be 192,000 m^3 of runoff water moving through and around the tyres per year or about 500 times more dilution than Abernethy (1994) used in his experiment.

An assessment of the pollution potential from the tyres can be made assuming 1000 EPU were used to build the scour protection and head wall structure. Assuming zinc, the most common "pollutant" in tyres, leached out at the first year rates, (600mg/kg/year) and tyre rubber is 1% zinc, then about 6mg/kg/year of zinc would leach out of the 1000 EPU in the scour mats and head walls built for the culvert. The concentration would then be about 0.3 µg/L or about 20 times below (5% of) the detection level and 16,000 times below the drinking water standard. If zinc leached out at 0.2 mg/kg/year which is the average over the 50 year life of the project, then the concentration would be 0.01 µg/L (0.2% of the detection level).

4.2 Drop in Leaching Rate with Time

Abernethy goes on to answer another critical question in his 1996 paper - "Do tyres continue to leach at the same rate?" He published the results of his enquiries after several follow-up experiments and the answer was a definite NO. As the paper states:

> "The rate of chemical release decreased during each tire submersion period in the flow-through tests, probably because of a continuous process of leaching." (Abernethy, et al 1996)

Tyres leach relatively quickly at the start of soaking but slow down to the point where a dilution of water that was lethal the first week of soaking has no impact after 80 days. Using Abernethy, et al's data, the following graph of lethality and concentration versus time can be plotted.

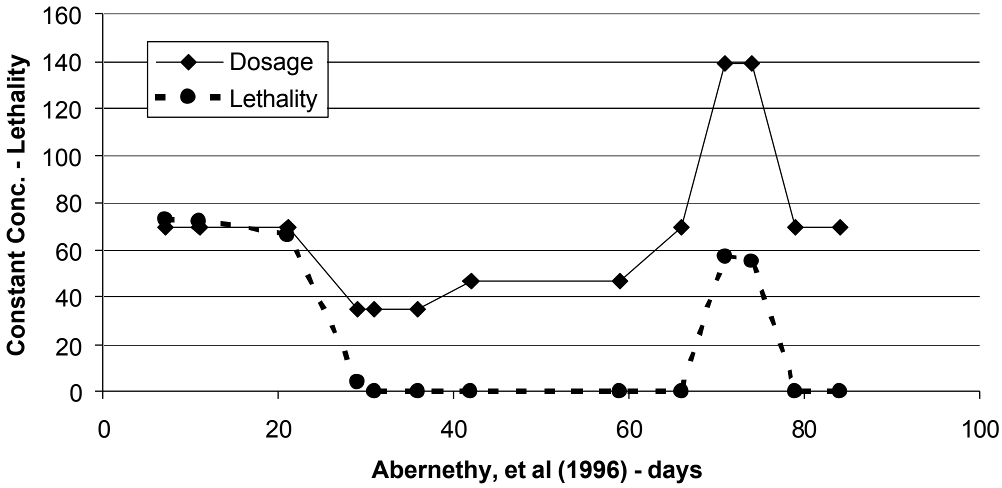

Figure 1 – Plot of Lethality and Concentration versus Days based on the data in Abernethy, et al (1996)

Figure 1 shows that in the first 20 days of the experiment, a concentration of about 70 resulted in a toxicity of about 70, but later in the experiment at days 79 and 85, a concentration of 70 results in no toxicity to the rainbow trout fry at all. This is a very strong indication that the water that the tyres are soaking in is becoming less and less toxic as time passes.

A similar result is shown in Figure 2 using the data of Goudey and Barton (1994). In Goudey and Barton's experiment the same dosage was given every day and the lethality dropped significantly over the 52 days of the experiment. Figure 2 shows the dosage line assuming that the dosage drops by 0.1 mg/kg per day rather than staying at 10 through the entire experiment. The graph shows that the lethality follows this line very closely, indicating again that the toxicity of "tyre water" drops significantly over time. The five day average lethality has been used to smooth out the up and down swings in the lethality that occurred in Goudey and Barton's experiment.

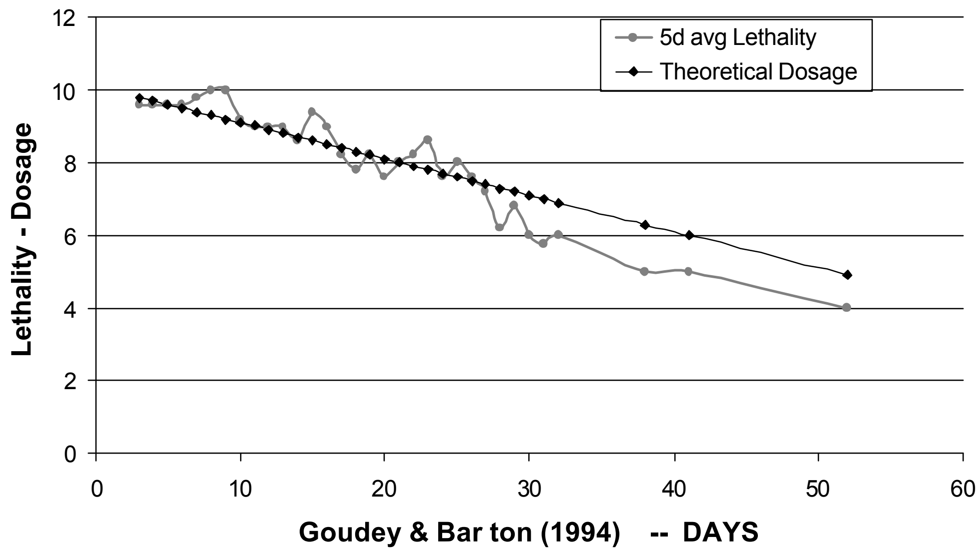

Figure 2 - Plot of Lethality and Theoretical dosage versus Days based on the data in Goudey and Barton (1994)

4.3 Summary of Review of Static Tyre Water Research

In summary, it is nearly impossible to make a tyre water that kills fish outside the lab by using tyre derived products in a civil engineering project. First, if there is no water then there will be no leaching. Many tyre derived products are dry most of the time or all of the time so they will not leach. Second, if there is too much water, the concentration of the pollutants will be undetectable. Third, over the long term (more than six months) there are no significant leachates even with exactly the correct volume of water. Fourth, even in the lab conditions only the rainbow trout fry were affected.

When these factors are combined it is clear why there have not been "fish kill" incidents near any of the thousands of civil engineering projects that have been built around the world with tyre derived products.

5. MYTH 2 – LEACHATE FROM TYRE DERIVED PRODUCTS COULD BE A SIGNIFICANT ENVIRONMENTAL PROBLEM

There is little doubt that more tyre rubber is likely to be worn off a tyre as it revolves at 500 rpm on a hard surface like a road pavement than is likely to be leached off the tyre, molecule by molecule, in runoff water.

The same Environment Australia document that (Atech 2001) warns its readers that "tyres do leach both organic and inorganic substances," also notes that "A new 10 kg passenger car tyre can be expected to lose about 1.5kg of rubber as 'dust' during use or approximately 0.03 g per km." No effort is made to compare the total impact on the environment of these two impacts.

Assuming that there are 20 million Equivalent Passenger Tyre Units (EPU) disposed of each year in Australia and the average EPU loses 1.5 kg of dust during its life, then those 20 million EPU would put 30 million kg of tyre dust into the environment. Most of that 30 million kg will end up in Australia's waterways after it is washed off the roads.

A tyre that is saturated and leaches according to the pattern described in the work of Abernethy et al (1996) and Goudey and Barton (1994), loses about 1000 mg/kg over its life. Assuming a used tyre weighs 8.5 kg, if all 20 million tyres were used in tyre derived products that were fully saturated, the tyres would leach 170,000 kg of tyre rubber into the environment over their lifetime. In other words, the tyres on the road would have about 176 times (30 million kg / 170,000kg) more impact on the environment than the leachate from tyres. Since most tyres in tyre derived products are NOT permanently saturated, this is a worst case ratio.

It should also be considered that tyres or tyre shreds in a saturated environment would leach if they were not used in a civil engineering application. Dumped tyres would also leach at the same rate if saturated.

6. ENVIRONMENTAL BENEFITS

Too often only the negative aspects of a product are considered when discussing its environmental credentials. Using scrap tyres has many positive impacts. If the 20 million EPU of tyre derived products replaced its equivalent weight (170,000 tonnes) of virgin ready mix concrete:

- 21,000 tonnes of CO_2 would be prevented from getting into the environment,
- 76,000 m^3 of raw materials (limestone, shale, sand and aggregate) would not have to be excavated
- 85,000 kg of NO_x would not get into the atmosphere
- 11,000 kg of fine airborne particles (PM_{10}) would not get into the atmosphere
- 220 million Litres of water would be saved
- 1.6 million cubic metres of landfill space would be saved

Ready mix concrete is used only as an example of a commonly used building material. The quantities of resources used and wastes generated were estimated from the data available in the Carnegie Mellon Life Cycle Assessment website (www.eiolca.net). The conversions were made based on 1.6 MJ/kg of 40 MPa ready mix concrete reported in Alcorn and Wood (1998) and Glover (2001).

Not only is the environmental impact of tyre leachate hundreds of times less than the environmental impact of tyre wear on our roads, there are many environmental benefits to using tyre derived products.

7. CONCLUSIONS

Many factors go into the decision to buy a product. It has to meet all the consumers needs and probably has to make the consumer a little bit happy inside, as well. There are many ways that tyres can be reused with all the life cycle benefits that go with it, but the one element that seems to be stopping people from using them, is the threat of leaching and water pollution from tyre derived products.

Recycled tyre derived products meet consumers requirements in many ways, as well as having significant environmental benefits. There may be reasons that tyre derived products are not used in some applications, but it is unlikely that there would ever be a reason to eliminate the use of a recycled tyre technology because of concerns over leachate. The data shows that the risks are not significant.

It is important that regulators and decision makers who are considering the environmental impacts of products, look at all aspects of the environmental impacts. It is best that simplified statements like "tyres do leach both organic and inorganic substances" are looked at critically by the decision makers and evaluated under the conditions that will be encountered in their applications in the field.

REFERENCES

Abernethy, Scott, 1994, The Acute Lethality to Rainbow Trout of Water Contaminated by an Automobile Tire *Ontario Ministry of Environment and Energy, Aquatic Toxicology Section, Standards Development Branch*, ISBN 0-7778-2381-0

Abernethy, S.G., B.P. Montemayor and J.W. Penders, 1996, The Aquatic Toxicity of Scrap Automobile Tires, *Report prepared for: Waste Reduction Branch, Ontario Ministry of Environment and Energy*, PIBS 3509E

Alcorn, A. and P. Wood, 1998, New Zealand Building Materials Embodied Energy Coefficients Database, Volume II – Coefficients, *Centre for Building Performance Research, Victoria University of Wellington*, http://www.vuw.ac.nz/cbpr/documents/pdfs/ee-finalreport-vol2.pdf, viewed 18 Feb 05

Atech Group, 2001, A National Approach to Waste Tyres, *prepared for Environment Australia,* ISBN 0 642 54749 1, *a publication of the Commonwealth Department of Environment*

Carnegie Mellon Green Design Initiative Life Cycle Assessment Website, www.eiolca.net, ready mix concrete factors, viewed 18 February 2005

Collins, K.J., A.C. Jensen and S. Albert, 1995, A Review of Waste Tyre Utilisation in the Marine Environment, *Chemistry and Ecology* **10**: 205-216

Glover, Joanna, 2001, Which is Better? Steel, Concrete or Wood: A Comparison of Assessments on Three Building Materials In the Housing Sector, Department of Chemical Engineering, University of Sydney, Fourth Year Thesis, http://www.boralgreen.shares.green.net.au/research3/chap1.htm, viewed 18 February 2005

Goudey JS and BA Barton, 1992, The toxicity of scrap tire materials to aquatic organisms**.** *Report to Souris Basin Development Authority, Regina, Saskatchewan, Canada, by Hydroqual Laboratories Limited and Environmental Management Associates*, Calgary, Alberta, Canada

Nelson, S.M., G. Mueller, D.C. Hemphill, 1994, Identification of Tire Leachate Toxicants and a Risk Assessment of Water Quality Effects Using Tire Reefs in Canals, *Bulletin of Environmental Contamination and Toxicology*, **52**:574-581

NSW EPA, 2003, Consultation Paper: Extended Producer Responsibility Priority Statement, *prepared by Waste Management Section*, ISBN 0 7347 7555 5, EPA 2003/10

NSW DEC, 2004, Extended Producer Responsibility Priority Statement, *prepared by Waste Management Section of the Department of Environment and Conservation*, ISSN 1449-2512