The Coastal Marine Resource Center Policy Project

The CMRC.org

The Coastal Marine Resource Center
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The Effects of Crumb Rubber on Water Quality

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Abstract

This paper will present the arguments both for and against the use of crumb focusing on the implications for water quality and advance certain precautions and guidelines that may be taken to safeguard against potential hazards (Table 1, Recommendations for Containing and Managing Crumb Rubber). These are recommendations to prevent the release of crumb rubber into the surrounding environment and minimize the flow of water from fields to water sources and water bodies.

The potential hazards to water quality from crumb rubber may not justify a moratorium on the construction of synthetic fields, however officials involved in building these fields must be circumspect in their designs and take full account of the effects that crumb rubber may have on the surrounding environment and the water supply, aside from possible health effects. Additionally, with numerous sources citing the potential danger of crumb rubber, officials have the responsibility to search out alternatives and to further justify their use of crumb rubber with more research, a detailed site assessment, and benefit-cost analysis for large scale projects.

Introduction

The United States generates just under 300 million waste tires each year. Waste tire generation has become a growing concern amongst the public both for the congestion they create in our landfills and for the possible health and environmental effects that may be associated with the disposal of used tires. As a result, tire recycling has increased over 60% in the last decade (increase from 17% in 1990 to 80% in 2003).[1]

One increasingly popular use for these recycled tires is as an infill product to soften and increase resiliency of synthetic turf found on playgrounds and recreational areas. According to the New York City Parks Department, as of the end of 2007 there were 63 of these fields across New York City and another 16 are currently under construction.[2] In processing the rubber for playground surfaces, the steel belt from tires is separated with the use of magnets and the rubber is ground up to produce what is commonly referred to as "crumb rubber." The rubber pellets can range in size and texture but are generally ground to a pellet shape and range

[1] United States. Department of Environmental Protection. Management of Scrap Tires. 6 Sept. 2007. 29 Feb. 2008 <http://www.epa.gov/epaoswer/nonhw/muncpl/tires/basic.htm>.

[2] New York. Department of Parks and Recreation. Albert Montbellier Park To 'Sport' Three Synthetic Playing Fields. 9 Nov. 2007. 29 Feb. 2008 <http://www.nycgovparks.org/sub_newsroom/press_releases/press_releases.php?id=19970>.

from 1/8th to 1/4th of an inch (3 to 7 mm) in length.

Installation Process for Synthetic Fields

One of the main constituents of synthetic playing fields is rubber, a polymer used to make tires. Producing tires requires the process of vulcanization – placing rubber under high heat with the addition of sulfur and other additives. In making the tire itself, various additives go into the process to create a tire's specific attributes. One of the main additives, zinc, is used to speed up the vulcanization process.[3] The potential effects of zinc and other compounds contained in tires leaching into the environment will be discussed in a later section.

In constructing the field, there are six general steps.[4] The field is prepared and compacted then a base layer of crushed rock is laid. The turf is then rolled out and sealed with adhesive. Finally, to fill the pores and spaces in the turf, the rubber infill is spread across the turf generally with a drop spreader, and the edges are sealed.

Cost estimates vary depending on location specific factors, but in general, synthetic turf installation requires a large initial investment. The basic argument is that these expenses are recovered over the lifetime of the field versus a natural turf field because of reduced upkeep and increase user time.

Lemar Morrison, of the San Francisco Parks Department, estimates that synthetic turf installation costs approximately $800,000 per soccer pitch or field ($260,000 for natural turf) and, by eschewing traditional problems with rain and snow, increases "playable hours" anywhere from 50% to 100%.[5] These figures have been debated with claims that the costs for synthetic fields far surpass that of natural fields.[6]

Beyond the economics of turf fields, a long debate has unfolded concerning the environmental impacts of synthetic fields. Advocates of synthetic fields argue that the fields reduce the use of pesticides, fertilizers, and water and even reduce carbon emissions by removing the necessity to cut the grass. The counter, though, focuses on the toxins released from the recycled tires through leaching and problems associated with disposing of the crumb rubber. While acknowledging the lively debate on the health effects of synthetic fields ranging from ingestion, exposure to off-gassed toxins and even increased surface temperatures, this paper will focus on the effects of crumb rubber used on synthetic fields with primary attention to the effects on water.

Potential Damage as Marine Debris

There currently exists little in the literature studying the effects of crumb rubber as a source of physical water pollution in the form of marine debris. There is anecdotal evidence that crumb rubber does spill off of the fields and could very easily find its way into the combined sewer overflows (CSO) or as stormwater discharge from a heavy rain event.[7]

Without specific studies on the subject, proxies can aid in the discussion. The EPA, for example, has completed various studies on the impact of

[3] Verschoor, Anja. 2007. "Leaching of zinc from rubber infill on artificial turf." RIVM report 601774001. Available at: <http://demo.openrepository.com/rivm/bitstream/10029/11459/1/601774001.pdf>

[4] Information provided by: http://www.turfoutlet.com/installation.htm. Accessed: April 8, 2008. This site contains more detailed information on the subject.

[5] Morrison, Lemar. "Natural and Synthetic Turf: A Comparative Analysis." San Francisco Recreation & Parks. 20 Dec. 2005. 3 March 2008 <http://www.cityfieldsfoundation.org/Comparison_fieldturf.pdf>.

[6] See: http://cafnr.missouri.edu/research/turfgrass-costs.php

[7] See *Flood washes out turf field in New Rochelle, NY,* available at: http://www.synturf.org/waterdamage.html and *Artificial Turf Could Be Ruled Out,* available at: http://www.zwire.com/site/news.cfm?newsid=13834839&BRD=2256&PAG=461&dept_id=455823&rfi=6

plastic pellets in aquatic environments.[8] Plastic pellets, many similar in shape and size to crumb rubber pellets, are the base product used in processing other consumer plastic products. While crumb rubber pellets may vary in density to that of plastic pellets, both floating and sinking pellets can affect the aquatic environment.

Most studies on ingestion of marine debris focus on larger products but similar effects are conceivable on small marine animals. The National Oceanic and Atmospheric Administration (NOAA) notes several potential dangers. When mistaken as food, marine debris can create blockages in the esophagus and the intestinal tract and also introduce harmful toxins (to be discussed further) into the animal's system; each with potentially lethal effects.[9] Additionally, by ingesting the pellets, the organism can feel artificially satiated and suffer from reduced energy reserves.[10]

Leaching of Toxins and Water Quality Studies

In reviewing the literature, various parties have weighed in on both sides of the issue of whether crumb rubber poses a threat to water quality. One of the most often cited studies by proponents of crumb rubber is a French study conducted by Dr. Robert Moretto of the French Research Network (EEDEMS) in partnership with FieldTurf Tarkett, a turf installation company, Aliapur, a French government agency responsible for tire recycling, and ADEME, the French Environment and Energy Management Agency.[11]

The study collected water using a lysimeter (a device used to catch water through the pores of a surface) placed beneath the turf of a pitch in Lyon, France. The year-long study identified 112 compounds and substances in the crumb rubber at levels consistent with expected runoff and below water quality standards.[12] [13] However, this study's conclusions were based on the assessment of the risks of 16 of the 112 compounds found.[14]

Birkholtz et al. (2003) corroborate these findings but qualify the results by noting that without dilution, crumb rubber was toxic to a variety of aquatic species tested.[15] The authors note that dilution is likely through the runoff created by rainfall or snow. Furthermore, they add that toxicity declines through weathering or extended exposure to the surrounding environment. Additionally, toxicity has been shown to decrease as salinity increases, which suggests that tire leachate is probably a greater threat to freshwater systems.[16]

Zinc leachate from crumb rubber infill may pose a threat to both ground and surface water. A recent Dutch study found zinc emissions to increase over the duration of the infill's

[8] Environmental Protection Agency. Office of Water. Plastic Pellets in the Aquatic Environment Sources and Recommendations. EPA 842-S-93-001. 1993 .

[9] Poster (pdf) available at: http://sero.nmfs.noaa.gov/pr/pdf/Marine Debris in GOM.pdf

[10] Environmental Protection Agency. Office of Water. Plastic Pellets in the Aquatic Environment Sources and Recommendations. EPA 842-S-93-001. 1993 .

[11] Moretto, Robert. 2007. "Enviromental and health assessment of the use of elastomer granulates (virgin and from used tyres) as filling in third-generation artificial turf." http://www.aliapur.fr/media/files/etudes_documents/Environmental_Study_Report_EN.pdf

[12] For a complete list of substances found and those specifically assessed, see pg. 24 of the Moretto (footnote 11) report.

[13] This list does not include elements found to be leaching from crumb rubber. The Connecticut Agricultural Experiment Station's report, "Examination of Crumb Rubber Produced From Recycled Tires" found five leached elements to be present: zinc, selenium, lead and cadmium. The report is available at: <http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/examinationofcrumbrubberac005.pdf>

[14] Brown, David. 2007. "Artificial Turf." Environment and Human Health, Inc.

[15] Birkholz, D.A., K. Belton and T. Guidotti. "Toxicological Evaluation of Hazard Assessment of Tire Crumb for Use on Public Playgrounds." Journal of Air and Waste Mgt Assoc. 53 (2003): 903-907. <http://www.shercomindustries.com/industries/birkholz-crumb safety paper.pdf>

[16] Hartwell, S.I., D.M. Jordahl, and C.E.O. Dawson. "The Effect of Salinity on Tire Leachate Toxicity." Water, Air,& Soil Pollution. 121.4 (2000): 119 – 131.

lifespan.[17] Furthermore, the study found the zinc

leachate to pose a potential threat to the drainage from the playing fields. While Vershoor[18] concluded that the leachate would not affect human health, it could damage marine biota and the surrounding environment if concentrations are significant.

Furthermore, various studies testing contamination with cut or scrap tires have produced some rather alarming results. One study from the Canadian government found that all rainbow trout exposed to water containing scrap tires for 60 days died within 24 hours.[19] Various other studies exist on other marine life; many with similar effects.[20] For example, two invertebrate species were exposed to 10 mL of water with a single piece of scrap tire. Within 24 hours, all of the species of one invertebrate died while the other invertebrate had varying mortality levels depending on the brand of tire placed in the water.[21]

Day et al.[22], in a related study, examined the effects of three separate whole tires – one from a floating breakwater, one road-worn tire, and one new tire – immersed in water. The study found the water from both the new and used tire to contain toxic leachate and proved fatal to rainbow trout. The water from the used tire was more toxic however and remained toxic for 24 days longer than the water from the new tire.

Additionally, tires contain a number of other metals and chemicals including polycyclic aromatic hydrocarbons (PAHs) that are thought to be hazardous to the environment. While limited, there exists related studies on the potential for PAHs to contaminate the local water supply. Valle et al. add, "PAHs elicit concern for several reasons: they are directly toxic to marine animals; they are harmful to humans; and PAH metabolites are potent animal and human carcinogens."[23] A 2007 article by Dr. William Crane of CUNY and Dr. Jim Zhang of Rutgers University found exceedingly high levels of 6 PAHs (and a high zinc content) from samples taken from Manhattan's Riverside Park synthetic field. The studies were somewhat elementary however, and again signify only the necessity for caution rather than categorical proof of threat.[24]

Recommendations

A number of variables exist in determining the likelihood of aquatic contamination from crumb rubber. Drainage characteristics and proximity to water sources play a large role in the physical transport of the crumb rubber pellets and the effect contaminants have on water quality. Additionally, dilution from various water sources

[17] Verschoor, Anja. 2007. "Leaching of zinc from rubber infill on artificial turf." RIVM report 601774001. Available at:<http://demo.openrepository.com/rivm/bitstream/10029/11459/1/601774001.pdf>

[18] Ibid

[19] Kellough RM. Effects of scrap automobile tires in water. Ontario Ministry of the Environment, Toronto, Waste Management Branch, 1991. In Gualtieri, Maurizio, Adrioletti, M., Vismara, C., Milani, M., and Camtini, M. "Toxicity of tire debris leachates." Environment International 31 (2005): 723 – 730

[20] For an extensive account of many of rubber leachate studies see: "An Assessment of Environmental Toxicity and Potential Contamination from Artificial Turf using Shredded or Crumb Rubber" by John Sullivan. Available at: http://bainbridgenotes.files.wordpress.com/2008/01/sullivanreport.pdf. And the report from the Norwegian Institute for Water Research available at: http://www.isss.de/conferences/Dresden2006/Technical/NIVA Engelsk.pdf (as of March 23, 2008). Additionally, for a series responses from the turf industry see: http://www.fieldturf.com/sbrfacts/

[21] Goudey, J.S. and B.A. Barton. 1992. The toxicity of scrap tire materials to selected aquatic organisms. A report prepared for the Souris Basis Development Authority, Regina, Saskatchewan. In Sullivan, John. 2006. "An Assessment of Environmental Toxicity and Potential Contamination from Artificial Turf Using Shredded or Crumb Rubber." Turfgrass Producers International.

[22] Day, K.E., K.E. Holtze, J.L. Metcalfe-Smith, C.T. Bishop, and B.J Dutka. "Toxicity of leachate from automobile tires to aquatic biota." Chemosphere. 27.5 (1993): 665 – 675.

[23] Valle, Sandra, M.A. Panero and L. Shor. Pollution Prevention and Management Strategies for Polycyclic Aromatic Hydrocarbons in the New York/New Jersey Harbor. New York: Harbor Consortium of the New York Academy of Science, 2007. 39.

[24] Article can be found at: http://healthychild.org/resources/article/hazardous_chemicals_in_synthetic_turf/(accessed March 25, 2008).

(rain, snow, irrigation, etc) could assuage the threat of the leached materials from the field.[25] The ability for synthetic fields to properly drain runoff is debatable but it does appear that natural fields provide a better system for drainage and filtering qualities, thus reducing the contamination potential.[26]

In any case, there exists no evidence to conclusively extinguish the debate over the use of crumb rubber and therefore, the precautionary principle – if an action may cause harm to the public or the environment, then it is the burden of the proponent of said action to provide proof of legitimacy – still holds and still requires a greater scientific basis.

The focus for this paper is on issues of water quality in relation to crumb rubber. There is an entirely separate debate over the health effects of the product as well. In general, there appears to be more literature citing the dangers of crumb rubber and the leaching of zinc[27] in particular, but many such studies contain various caveats or remain still too limited.

Further study must be undertaken both to continue the study of the ecotoxicity of crumb rubber and to explore the pathways of potential pollution from synthetic fields before one can categorically denounce the use of crumb rubber. Site specific tests, including determining existing water quality and evaluating exposure risks, should be undertaken as well before constructing fields. While limited, studies show that the pH of exposed water aids in the leaching rate.[28] Higher leaching rates occur at more acidic pH levels. Taken with other factors, these variables should be documented and accounted for in advance of construction.

The reality of the situation, however, is that these fields are still being constructed despite potential risks. With this being the case, there are measures that can be taken in the interim before research can definitively point for or against synthetic turf and the use of crumb rubber (See Table 1, Recommendations for Containing and Managing Crumb Rubber).

There are various alternatives to crumb rubber, these include: silica sand, coated granules of silica, and TPE, a polymer pellet infill.[29] However, these materials may not be as cost effective, they do no address the recycling issue as does crumb rubber and there are no comprehensive tests on the safety of these materials.

Additionally, precautionary measures can be taken within the design layout of the field aside from those required by most states. Valle et al. note that contamination, beyond proximity to a water source, depends on the distribution of permeable land surfaces and the hydrodynamics of stormwater, sewers, and surface water features.[30] There are a number of ways that these features can be used to creatively minimize risk.

In landscaping, the EPA suggests several options to minimize stormwater runoff: install permeable pavement (allows runoff to soak through), use mosquito-proof rain barrels to collect rainwater at flow points (additional benefit is that the water can be reused), install rain gardens or swales (areas of native plants to collect overland flow),

[25] Sullivan, David. 2006. "An Assessment of Environmental Toxicity and Potential Contamination from Artificial Turf using Shredded or Crumb Rubber."
[26] See the Delaware Riverkeeper Fact Sheet for further reading of this topic at: http://www.delawareriverkeeper.org/newsresources/factsheet.asp?ID=50(accessed March 25, 2008).
[27] Aside from various citations throughout this article, see: Brown, David. "Artificial Turf: Exposures to ground-up rubber tires, athletic fields, playgrounds, gardening mulch." New Haven, CT: Environmental & Human Health, Inc, 2007.
[28] Various studies pg. 25 in - Sullivan, John. 2006. "An Assessment of Environmental Toxicity and Potential Contamination from Artificial Turf Using Shredded or Crumb Rubber." Turfgrass Producers International.
[29] Costa, Annie. "Crumb Rubber Infill Alternatives." *EzineArticles* 04 December 2007. 12 April 2008 <http://ezinearticles.com/?Crumb-Rubber-Infill-Alternatives&id=864335>.
[30] Valle, Sandra, M.A. Panero and L. Shor. Pollution Prevention and Management Strategies for Polycyclic Aromatic Hydrocarbons in the New York/New Jersey Harbor. New York: Harbor Consortium of the New York Academy of Science, 2007.

and plant vegetated strips (native plants or grasses along roadways or streams to trap pollutants).[31] Overall, the goal is to decrease the amount of water that flows from the fields to water sources and these projects combined with minimal contact with impervious surfaces can facilitate this.[32]

The EPA also offers guidelines on properly handling and transporting pellets, which may be apropos to crumb rubber distribution as well. Guidelines include measures such as proper education of haulers as well as sufficient inspection of shipping vehicles and containers. Moreover, secondary containment systems and reinforced crates or bags would reduce accidental spillage and effective clean-up procedures would mitigate further loss after the fact.[33]

While the scientific debate evolves, measures such as those in Table 1 can be taken while general public awareness is equally important.

Conclusion

The quandary that this situation poses is such that on the one hand, crumb-rubber is a means for using some of the many waste tires crowding our landfills. However, if and when synthetic fields are retired and the crumb rubber is disposed of, the synthetic fields will have served as a temporary stopover for used tires in crumb form, eventually destined for landfills. Crumb rubber is not a solution to tire waste if the outcome leads to a degraded environment.

A moratorium on the construction of synthetic fields is perhaps premature but officials involved in building these fields must be circumspect in their designs and take full account of the effects that crumb rubber may have on the surrounding environment and the water supply (aside from possible health effects). Additionally, with numerous sources citing the potential danger of crumb rubber, officials have the responsibility to search out alternatives and to further justify their use of crumb rubber with a detailed site assessment and benefit-cost analysis for large scale projects.

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[31] Environmental Protection Agency. Office of Water. After the Storm. *EPA 833-B-03-002. 2003.*
[32] San Francisco Public Utilities Commission. Stormwater Design Guidelines. 2007.
[33] Environmental Protection Agency. Office of Water. Plastic Pellets in the Aquatic Environment Sources and Recommendations. EPA 842-S-93-001. 1993 .

Table 1. Recommendations for Containing and Managing Crumb Rubber

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Recommendation	*Description*
Additional Research	Additional research should be conducted from a variety of capable entities to determine the true health and environmental costs of using crumb rubber on synthetic fields. These studies must systematically address the issues surrounding rubber leachate and conclusively identify the actual risk to humans and the surrounding environment.
Consider Alternatives to Crumb Rubber	Possible alternatives include silica sand, coated granules of silica, and TPE, a polymer pellet infill.
Take into account potential for Zinc and PAH release.	Any proposal for a synthetic field with the use of crumb-rubber infill must fully address overall leachate potential with particular focus on zinc and PAH contamination.
Locate storm drains where they will not receive crumb rubber	Ensure storm drains are not placed on a field where crumb rubber can be carried by storm water and enter drains during rain events or during snow melt.
Install measures around the site to prevent storm water runoff from entering field	Prevent runoff from surrounding areas from entering or passing through the field. Do this by minimizing impervious surfaces, grading surrounding surfaces to convey storm water away from the site, and by filtering runoff using landscaping and other "green" storm water conveyance measures.
Ensure the field is level	Prevent storm water from leaving the field by grading it level.
Curb or buffer the field to prevent storm water from leaving the field.	Use curbing or grass buffers around the field to prevent storm water from leaving the field and entering nearby storm drains, wetlands, or waterways.
Ensure crumb rubber is the most economically feasible solution.	Conduct a benefit-cost analysis for large scale projects. Simple benefit-cost analysis must be able to withstand close scrutiny. Various reports exist showing conflicting conclusions on feasibility. Analysis includes simple determinants such as the expected life of either turf or sod, maintenance costs, and replacement expenses.
Develop plan for transporting and disposing of crumb rubber when field is replaced or abandoned.	Crumb rubber must be vacuumed or collected by other means when field is retired, abandoned, replaced, or no longer in use.
Contain crumb rubber if transported to landfill or other location.	Collected crumb rubber must be bagged and contained to prevent release during transport.
Periodically inspect area surrounding field for crumb rubber released from the site	Inspect surrounding areas to identify if crumb rubber is not staying on the field. Take measures to alter drainage or install buffers. Collect crumb rubber that has left the field and dispose. Only reapply to field if drainage is corrected.