What do we do with these old tires?

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Highlights

- Tire derived aggregate will retain phosphate
- Tire derived aggregate will release zinc, copper and iron
- If we can mitigate metal leaching, we can use tire derived aggregate in underground stormwater storage and infiltration to retain phosphate

Introduction

Tires discarded after their use in vehicles are also a problem for all countries. The USA alone is generating 300 millions used tires a year. Any mismanagement of discarded tires poses serious environmental problems. For example, the burning of tires creates an odorous, toxic smoke due to the presence of many oils and chemicals used in the manufacturing process; the discarded tires in open spaces are an ideal breeding ground for mosquitos, and finally landfilling discarded tires requires huge significant space and the tires can hold explosive gases causing safety problems and reducing integrity reliability of landfill liners. Thus, discarded tires are a waste product which needs strategies for its reutilization.

This study is designed to provide an understanding of the water quality impacts of utilizing discarded tire waste as tire derived aggregate (TDA) for stormwater treatment, where exposure of water to the TDA will last for up to 72 hours in underground storage or infiltration systems. The leaching or adsorption of metals and phosphorus were investigated in controlled laboratory experiments under conditions similar to what would be experienced in underground storage and infiltration chambers.

Methodology

Experiments

Containers of 1 L wide mouth glass bottle were used as batch reactors. The bottles were first washed in 5% HNO_3, followed by rinsing of several times with distilled water. The initial weight of TDA was recorded followed by the rinsing of TDA with milli-Q water in a drain for ~3 minutes. After rinsing, TDA was allowed to dry and weighed again. The synthetic stormwater was added to fourteen different reactors, prepared according to six groups based upon the condition of metal wire (rasp) in the TDA: 1) rasp-on with no chloride, 2) rasp on with high chloride, 3) rasp off with no chloride, 4) rasp off with high chloride, 5) control with no chloride and 6) control with high chloride reactors. Triplet reactors were maintained for first four groups (group 1, 2, 3 and 4) while groups 5 and 6 were without replicates.

The reactors were first filled with 200-gram of TDA. Followed by addition of 600 mL of water, to maintain a TDA/water ratio of 1/3. TDA-stormwater mixture present in bottles were shaken by inversion for one minute at different times (0, 2h, 4h, 8h, 24h, 48h, 72h). In the first flush, there was some difficulty keeping the TDA submerged, although submergence was over 95%. After successful sampling over 72 hours, the bottles were drained and TDA was allowed to dry for two days. After drying of TDA, bottles were filled again to repeat the same experiments for the second and later flushes, where bottles were filled with 750 mL stormwater, resulting in a TDA/water ratio of 1:3.75 to assure that the TDA was fully submerged. The sampling times remained the same for the later flushes.

Sampling and Analysis

At each sampling time, 20 mL samples were collected into polypropylene tubes and preserved in 2% nitric acid for analysis using ICP-OES analysis of 16 metals. A second 5 ml sample was stored for IC analysis of chloride and phosphate. Both, unfiltered and filtered stormwater samples (using a 0.45 µm filter) were stored for IC analysis to look into the effect of suspended particles. The collected water samples were analyzed for the temperature, dissolved oxygen (DO) and pH using probes, for real time measurement.

Results and discussion

Total Phosphorous (TP)

Figure 2 indicates that the concentration of TP in the samples with TDA decreased over time. For example, the effluent samples from the reactors with rasp off in the fourth flush with carbonate buffer was seen to reduce to a TP concentration of 0.01 mg/L from an initial concentration of 0.17 mg/L. Similarly, in the fourth flush with carbonate buffer, the TP concentration was observed to reduce to 0.08 mg/L from an initial concentration of 0.13 mg/L. Similar observation were made against all four flushes performed using synthetic stormwater. On the other hand, the control samples (samples without TDA) were seen to have no significant reduction were seen. For instance, TP concentration in the effluents from the control reactor were seen to be having a reduction of 0.01 mg/L from an initial concentration of 0.18 mg/L. Such reduction in the TP concentrations against the influent concentration from the reactors with TDA indicates adsorption of phosphate. The adsorption of phosphate could be attributed to the presence of different metals in the tires which combine with the metals. Observance of higher removal from the reactors with rasp-off TDA indicates that the removal of phosphorous was enhanced due to the rasping process, which does not remove all of the rasp and exposes more surface area to adsorption. The impact of chloride on the adsorption of phosphorous could not be clearly identified as no regular pattern of differences were observed.

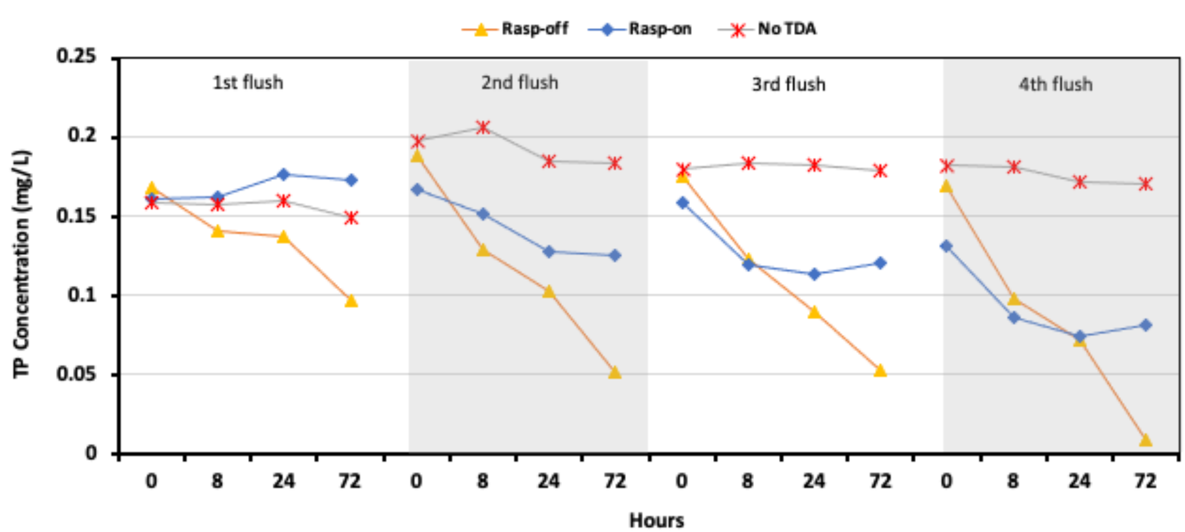

Figure 1. TP concentration using carbonate buffer..

Zinc (Zn)

Figure 2 shows that the zinc concentration was higher in the reactors with TDA, while the control reactors had no Zn concentration. For example, in the sixth flush, effluent Zn concentration from the rasp-off and rasp-on reactors with low Cl reactor was 0.5 and 0.2 mg/L while the control reactors had only 0.02 mg/L. It should also be noted that the chronic water quality in fresh water for aquatic life for Zn is 0.117 mg/L. Thus, it can be concluded that TDA leaches zinc, which can be attributed to the presence of zinc oxide as a tire component. On the other hand, Zn release was higher in the reactors with rasp off TDA than the reactors with rasp-off TDA. Higher Zn release could be attributed to greater exposure of surfaces due to rasping, which would increase the release of Zn from TDA. No conclusions could be made about the impact of chloride on Zn leaching.

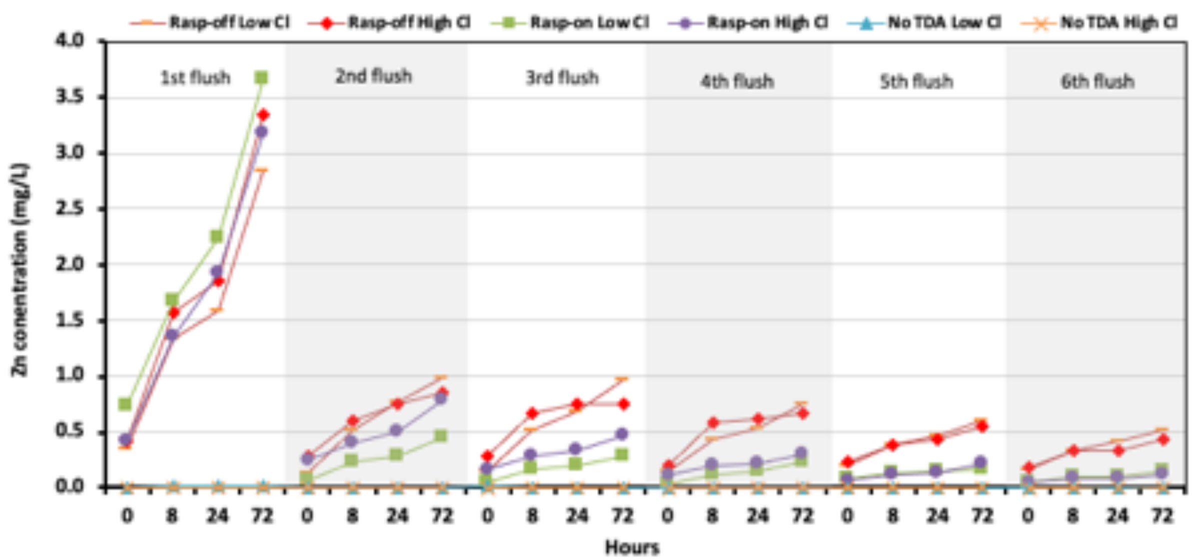

Figure 2. Zn concentration using phosphate buffer over multiple flushes.

Conclusions and future work

1. TDA can be used in underground runoff storage and infiltration as a phosphate reduction technology.
2. TDA does release substantial amounts of zinc, which must be captured before it enters storm sewers and the groundwater system.
3. A combination of media will be used to mitigate zinc release while allowing for phosphate capture.