STORMWATER POLLUTANT CALCULATION

Purpose & Goals

Purpose: Building off of the Stormwater Runoff Calculation activity, this activity goes into more detail concerning annual runoff as well as estimating pollutant loads. Students will learn to think like professionals in engineering and water resource fields.

Goal: Using the schoolyard, the students develop an understanding of stormwater runoff and pollutant load over time. Students can apply trends found in this activity to any landuse type, and explain the landuse's implications on water resources.

Standards

Time: 45 min - 1 hr **Grades:** 7-12

STEM Math: 4.1.1.5., 4.2.1.1., 4.2.2.1., 5.1.1.4., 5.1.3.4., 5.2.1.1., 6.3.1.3.

STEM Science: 4.1.2.1.1., 4.1.2.2.1., 4.3.2.3.1., 4.3.4.1.1., 5.1.1.1.4., 5.3.1.2.2., 5.1.3.4.2., 6.1.2.1.1., 7.1.3.4.1., 7.1.3.4.2., 8.1.3.4.2., 8.3.2.3.1., 8.3.2.3.2., 8.3.4.1.2., 9.1.2.2.2.

Preparation & Materials

With more intricate calculations in this lesson than the stormwater runoff lesson, manually measuring school yard surface areas may not be time permitting. This activity fits an indoor classroom setting focused on calculations and resulting discussion.

- Map of schoolyard (PDF provided by VLAWMO)
- Calculators
- Runoff coefficient tables & calculation worksheet
- Surface coverage measurements (provided by VLAWMO)
- Pencils & scratch paper

Procedure

1. If students have not done the stormwater runoff calculation lesson, start with the concept that whatever's on the land's surface impacts water quality through runoff. If a rainfall event is large enough to generate runoff, whatever is on the surface goes to the nearest lake or river, and this in turn impacts groundwater and downstream natural resources such as gulf fisheries. Engineers and stormwater professionals utilize these calculations to plan developments, natural areas, and stormwater management practices such as raingardens. These calculations are part of a runoff model called MIDS, created by the Minnesota Pollution Control Agency. While experts would fine-tune the equations to fit a given site, a general application provides an estimate suitable for learning about the process. While the VLAWMO stormwater runoff lesson calculates according to a single rain event, this pollutant calculation lesson takes into account the annual precipitation.
2. Calculate annual rainfall depth (in) for each landuse surface, using corresponding runoff coefficients.
3. Calculate annual stormwater runoff volume (ft^3) from each landuse surface.
4. Calculate pollutant loads (lb.) from each landuse surface and total the findings. Calculate for both TSS (total suspended solids) and TP (total phosphorous). Suspended soilds are things such as sand particles, which carry nurtients and contaminants, and phosphorous, which creates an excess that causes lower dissolved oxygen, fish kills, and algae blooms. Customize the two surface area's acerage to analyze what difference this makes in terms of pollutant load.

Reflection

1. Which surfaces shed the most pollutants? Are these also the surfaces with the most surface area, or the surfaces that generate the most runoff? Create custom landuse surface totals out of the data and analyze the combination of various surfaces.
2. How do total annual rainfall and the runoff coefficient effect annual runoff depth? What would it take to maintain a low annual runoff if a site had high annual rainfall and a high runoff coefficient? What if there was a high annual rainfall and a low runoff coefficient?
3. Describe the problems and assets for each region of the schoolyard (N/S/E/W). Balancing these problems and assets, where would a water quality project be placed to have the greatest impact on water quality?
4. After analyzing your schoolyard, what strategies do you think the building planners had for runoff? Would you have done anything differently?

Assessment

At the end of the activity, students will have obtained an estimated pollutant load for each landuse surface on the schoolyard, as well as a total pollutant load for suspended solids phosphorous. Students will be able to explain which land surface covers are benefitial, and which are risky, to water quality.

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EST 1983
Vadnais Lake Area Water Management Organization

Equation Descriptions

1. Annual runoff depth:

$$D_r = P \times P_j \times R_v$$

D_r = Annual runoff depth (in)
P = Total annual rainfall depth (in)

Found on websites like USclimatedata.com. Saint Paul's average is 32.01"

P_j = Fraction of annual rainfall events that produce runoff (.9).

Obtained by the runoff reduction method created by the Center for Watershed Protection, 2008.
Consistently setting this at .9 is recommended by the Minnesota Pollution Control Agency.

R_v = Runoff coefficient

Refer to the coefficient table with coefficients provided by VLAWMO on the calculation worksheet.

2. Annual stormwater runoff volume:

$$R = D_r \times A \times 3{,}630$$

R = Annual stormwater runoff volume (ft^3)
D_r = Annual runoff depth (in)
A = Surface area of landuse in acres
3,630 = Conversion factor to convert the final result into cubic feet.

3. Pollutant loads:

$$L = R \times C \times 6.243 \times 10^{-5}$$

L = Pollutant load (lb)
R = Annual stormwater runoff volume (ft^3)
C = Average annual polltant concentration in mg/l

Calculate each landuse surface for total suspended solids (TSS) and total phosphorous (TP), seperately.
TSS: 54.5 mg/L TP: 0.3 mg/L Average concentrations provided by the Minnesota Pollution Control Agency

6.243×10^{-5} = Conversion factor to convert the final result into lbs.

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Additional Notes

Coefficients: Coefficients are rates of runoff generated by research. Different surface areas have different rates of runoff. So depending on the surface, some water will infiltrate into the ground, some will runoff, and some will be taken up by plants, and some lost to evaporation.

While pavement is an easy and consistent estimation, coefficients for natural areas varies depending on soil type. Consolidating insight from a variety of sources, VLAWMO has gathered coefficients that are used in the Twin Cities region. The class may walk around the schoolyard to better observe soil types for a closer estimation of runoff. If soil is generally sandy, decrease the turf grass coeffficient by .5 and if clay, increase it by .5. You may choose to deliniate between sloped or flat turfgrass and estimate the square footage by sub dividing the existing square footage, and again adding .5 for areas with a slope.

Reflection questions: Common surface contaminants on pavement are road salt, leaky oil and brake dust from cars, leaves getting into stormdrains, sand and other sedmient, and litter. Grass, while having a lower runoff rate, still has fertilizer that bring excess nutrients and algae blooms into water, and pet waste, which has many nutrients, parasites, and worms, and harmful bacteria that should be kept out of water.

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Supplemental tools:

Videos about stormwater runoff - all or portions of each video add to an understanding on the issues behind the calculations.

MPCA on TSS: https://www.youtube.com/watch?v=j41vwHg72as
University of Minnesota: https://www.youtube.com/watch?v=_sI-GBwNbLM
Puget Sound: https://www.youtube.com/watch?v=8b0X6EEJs3Q
Michigan: https://www.youtube.com/watch?v=N9HUoMnvsRw
Metro Blooms, Minneapolis: https://www.youtube.com/watch?v=42LYqrj4qqY